

**How does Urbanization Contribute to Western Fast Food
Consumption and Childhood Obesity in China—
The Mediating Role of Food Environment**

By

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Abstract

Background: Childhood obesity prevalence in China has been rising rapidly over the past three decades, while China has been under a rapid economic transition including the urbanization process, accompanied by dramatic changes in the food environment including the widespread of Western fast food restaurants. This study aims to study the linkage between urbanization and its impact on the food environments and childhood obesity, with a particular interest in Western fast food consumption.

Methods: Longitudinal data collected during 2004- 2011 in the China Health and Nutrition Survey (CHNS) were used. CHNS is an open cohort study following households started in 1989 until recently. It covers a wide range of regions in terms of geographical locations, socio- economic status and dietary habits. This study focused on the sample of 1,878 children aged two to eighteen years, and conducted longitudinal data analyses and structural equation modeling to explore the impact of urbanization on food environments, on children's Western fast food consumption and their weight status, as well as the role that the food environments played for the latter two.

Results: Urbanization was associated with all components of the food environment, including the odds of having fast food restaurants (OR=2.78, 95% CI: 2.18~3.54), other indoor restaurants (OR=2.93, 95% CI: 2.28~3.76) , supermarkets (OR=2.43, 95% CI: 2.04~2.89) and open- air markets (OR=2.56, 95% CI: 1.77~3.70), food prices for apples ($\beta=0.06$, 95% CI: 0.04~0.08) and lean pork ($\beta=0.02$, 95% CI: 0.01~0.03), as well as the community norms for fast food consumption (RR=1.28, 95% CI: 1.22~1.33), fast food preferences (RR=1.09, 95% CI: 1.06~1.12) and nutrition knowledge (RR=1.02, 95% CI: 1.01~1.03). It was also associated with Western fast food consumption in the past three months among both boys (OR=1.98, 95% CI: 1.68~2.35) and girls (OR=1.88, 95% CI: 1.60~2.22), while the socio- cultural environment and food prices mediated such association. Urbanization was also found to be positively related to the odds of being overweight or obese among boys (OR=1.38, 95% CI: 1.13~1.67) but not girls, and the density of fast food outlets, food prices for apples or flour, and community norms for nutrition knowledge mediated such relationship.

Conclusions: Urbanization contributed to shifts in various types and dimensions of the food environments,

and increased Western fast food consumption and obesity rates among children in China over the past decade. Chinese children tended to favor Western fast food, which might partially result in increased obesity rate. Public health professionals and policy makers need to pay attention to and address the side effects of urbanization and the spread of fast food restaurants to fight the growing childhood obesity epidemic.

Advisors: Youfa Wang, MD, PhD, MS; Lawrence Cheskin, MD

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Enter through the narrow gate. For wide is the gate and broad is the road that leads to destruction, and many enter through it. But small is the gate and narrow the road that leads to life, and only a few find it.

-Matthew 7:13-14 New International Version (NIV)

For me, finishing my PhD training at Hopkins and completing this dissertation is a long journey.

Though the process has been challenging, it leads to a life, completely different from what I have ever imagined before, and I have never regretted it, that I started the long journey years ago when I came to the U.S. from China with my dreams to pursue a successful career.

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Acronyms and Abbreviations

ANGELO	ANalysis Grid for Elements Linked to Obesity
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CHNS	China Health and Nutrition Survey
CNSSCH	Chinese National Survey on Students Constitution and Health
COPD	Chronic Obstructive Pulmonary Disease
CPI	Consumer Price Index
CVD	Cardiovascular Disease
FF	Fast Food
FFQ	Food Frequency Questionnaire
GDP	Gross Domestic Product
NAICS	North American Industry Classification System
NCD	Non-Communicable Disease
PA	Physical Activity
PSA	Public Service Announcements
PSU	Primary Sampling Units
SES	Socio-Economic Status
SIC	Standard Industrial Classification

CHAPTER 1: INTRODUCTION AND SPECIFIC AIMS

1.1 Introduction

The rate of childhood obesity in China has been skyrocketing over the past three decades. The Chinese National Survey on Students' Constitution and Health (CNSSCH), a nationally representative survey monitored school- age children's body constitution and health on an annual basis, and found that approximately 15% school- age children and adolescents being investigated were either overweight or obese in 2010, compared to only 1-2% in 1985 (JI & CHEN, 2013; Song et al., 2015).

The rates are much higher in urban areas than in rural areas, and in boys than in girls. The CNSSCH data show the 32.6% boys and 19.1% girls living in large coastal cities were either overweight or obese in 2010, which were comparable to their American counterparts (Ogden, Carroll, Kit, & Flegal, 2012). Those cities were the first regions undergoing rapid economic transformations and becoming highly urbanized in China since its economic reforms starting from the late 1980s. Does the imbalance in the growth of childhood obesity rate in China have anything to do with differential levels of urbanization in those regions?

Part of the answer is yes. Empirical studies in China have suggested a potential link between urbanization and individual lifestyles, which undoubtedly contributed to the emerging obesity rate. Results from two national nutrition and health surveys showed that urban residents consumed more animal meat products, more snacks and fewer grains than their rural counterparts, although food consumptions of the rural residents were beginning to catch up with those of the urban ones since the 2000s (Wang, Zhai, Zhang, & Popkin, 2012; Zhai et al., 2005). Meanwhile, urbanization has been found to be positively associated with a sedentary lifestyle and decreased physical activity (PA) levels (Monda, Gordon-Larsen, Stevens, & Popkin, 2007; Ng, Norton, & Popkin, 2009).

Even if the relationship between urbanization, individual lifestyles and childhood obesity has been established, the underlying mechanisms remain unknown. What lies between urbanization and lifestyles? My assumption is community food environments. Whether built environment contributes to obesity remains a

controversy. Despite the large quantity of empirical studies and systematic reviews on this topic, the conclusion is still indecisive (Ding & Gebel, 2012; Durand, Andalib, Dunton, Wolch, & Pentz, 2011; Feng, Glass, Curriero, Stewart, & Schwartz, 2010). A major reason lies in the heterogeneities in those empirical studies, and difficulty in drawing a causal conclusion.

The immersion of the Western fast food (FF) industry into the Chinese local food market is noteworthy. Though a nationwide cohort study showed that Chinese children's average daily energy intake has declined by approximately one fifth, their fat intake has steadily increased from 54.8 in 1991 to 66.0 grams per day in 2009(Cui & Dibley, 2012). The shifts from a formerly plant-based diet to a westernized, high- fat diet indicate an ongoing nutrition transition, which comes along with increased consumptions of food-away-from-home, and changing food systems (Popkin, 1999; Popkin, Adair, & Ng, 2012). Of the changing food systems, the Western FF industry and its culture of efficiency and convenience may play a role during this transition process.

1.2 Study objectives and specific aims

To answer these questions and fill in the research gaps, this study was initiated. As part of a large National Institute of Health (NIH, U54HD070725, 1R01HD064685-01A1, R01DK81335-01A1)-funded international collaboration research project on childhood obesity, the overall objective of this longitudinal study is to use multi-level models and structural equation modeling techniques to examine the impact of urbanization on Western FF consumption and the risk of being overweight or obese among Chinese children; and to explore the mediating role of three dimensions of the community-level food environment: (1) the local food environment as the physical environment; (2) community-level food prices as the economic environment; and (3) community norms for diet knowledge, FF consumption and preferences as the community- level socio- cultural environments. The three specific aims are:

Aim 1: To investigate the impact of urbanization on three dimensions of the community-level food environment

(physical, economic, and socio-cultural) as reflected in the availability and proximity of various types of food outlets; food prices; and community norms for nutrition knowledge and Western FF consumption and preferences

Hypothesis 1a : At the community level, more urbanized communities have higher density of supermarkets and food serving establishments (including Western FF restaurants and other restaurants); while less urbanized communities have higher density of free markets;

Hypothesis 1b : At the community level, more urbanized communities have different food prices of grains, cooking oil, eggs and meat products, vegetables, fruits, milk and soft drinks compared to less urbanized communities;

Hypothesis 1c: At the community level, more urbanized communities have stronger community norms for Western FF preferences and Western FF consumption, but not for diet knowledge compared to less urbanized communities.

Aim 2: To investigate how urbanization affects children's Western FF consumption, and whether this relationship is mediated by three dimensions of the food environment (physical, economic, and socio-cultural).

Hypothesis 2a: After adjusting for age, gender, ethnicity, family SES and geographical regions, levels of urbanicity are associated with children's Western FF consumption, and this association is mediated by dimensions of the local food environment;

Hypothesis 2b: After adjusting for age, gender, ethnicity, family SES and geographical regions, children living in more urbanized communities consume more Western FF, and this association is mediated by prices of foods in that community;

Hypothesis 2c: After adjusting for age, gender, ethnicity, family SES and geographical regions, children living in more urbanized communities consume more Western FF, and this association is mediated by community norms for diet knowledge and Western FF preferences.

Aim 3: To investigate how urbanization affects children's weight status, and whether this relationship is mediated by three dimensions of the food environment (physical, economic, and socio-cultural).

Hypothesis 3a: After adjusting for age, gender, ethnicity, family SES and geographical regions, levels of urbanicity are associated with children's weight status, and this association is mediated by dimensions of the local food environment;

Hypothesis 3b: After adjusting for age, gender, ethnicity, family SES and geographical regions, children living in more urbanized communities are more likely to become overweight or obese, and this association is mediated by prices of foods in the community;

Hypothesis 3c: After adjusting for age, gender, ethnicity, family SES and geographical regions, children living in more urbanized communities are more likely to be overweight or obese, and this association is mediated by community norms for diet knowledge, and Western FF consumption and preferences.

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CHAPTER 2: REVIEW OF THE LITERATURE

2.1 OBESITY, CHILDHOOD OBESITY AND NCDs, WORLDWIDE AND IN CHINA

Obesity has become a global pandemic. The prevalence of overweight or obesity was 36.9% among men and 38.0 % among women globally in 2013. Meanwhile, 23.8% of boys and 22.6% of girls in developed countries, as well as 12.9% of boys and 13.4% of girls in developing countries were either overweight or obese (Ng et al., 2014).

Obesity dramatically increases the risk of non- communicable chronic diseases (NCDs), which is the top killer throughout the world. The three leading cause of death in 2010, including ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD) were all NCDs. Approximately 34.5 million people died of NCDs worldwide in 2010, accounting for two thirds of the total mortality (Lozano et al., 2012).

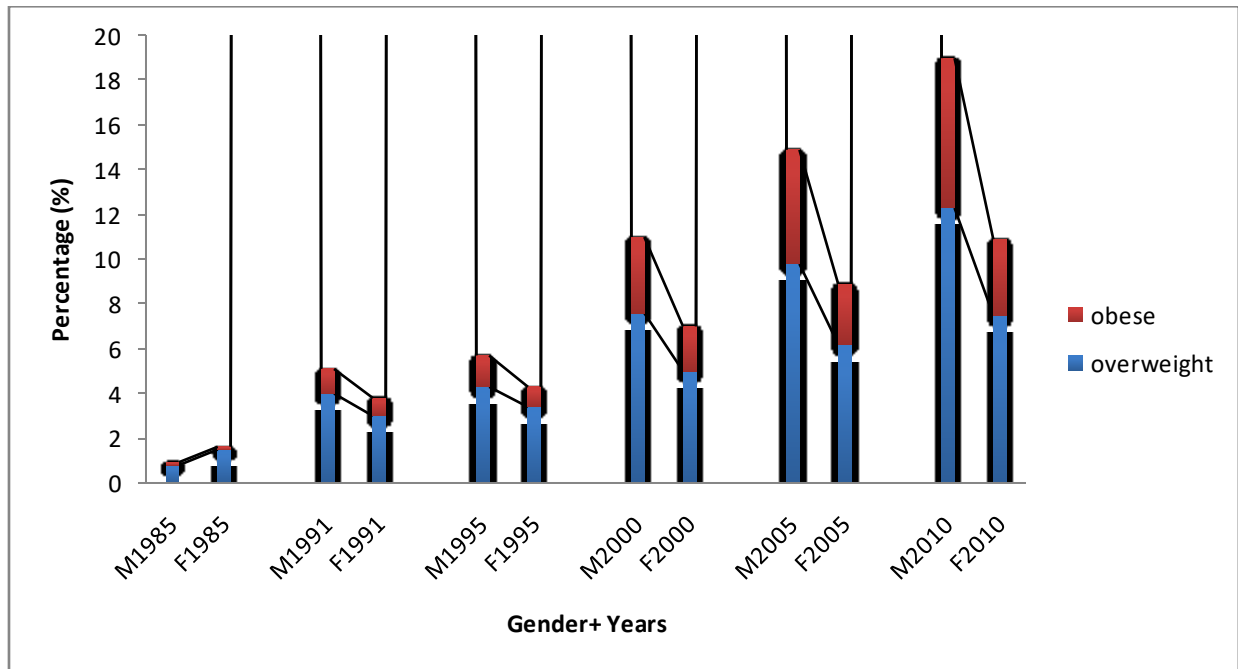
Being the most populous and largest developing country in the world, China is also facing an obesity epidemic (Wang, Mi, Shan, Wang, & Ge, 2006). Based on the World Health Organization (WHO) body mass index (BMI) cutoff points, the prevalence of overweight among Chinese adults has increased from 19.6% in 2004 to 28.0% in 2010, while the prevalence of obesity has risen from 3.3% in 2004 to 5.2% in 2010 (Jiang et al., 2015).

The problem with children is even severer. In the United States, 17.0% of children and adolescents were obese and 5.8% were extreme obese in 2011- 2014 (Ogden et al., 2016; Ogden, Carroll, Fryar, & Flegal, 2015). In China, the Chinese National Survey on Students' Constitution and Health (CNSSCH), the largest nationally representative survey on school children (7- 18 years old) in China reported that approximately 19.0% boys and 10.9% girls were either overweight or obese in 2010, as compared to 1- 2% in 1985 (JI & CHEN, 2013; C Y Ji & Cheng, 2009) (**Figure 1.1**). They were becoming more obese too: the 95th percentile of BMI distribution among younger Chinese children had exceeded that of their American counterparts and had been growing rapidly (Popkin, 2010).

Obesity in childhood is extremely detrimental to health, as overweight/obese children are at greater risk to become overweight or obese adults, and develop NCDs at an earlier stage of life (McCrindle, 2015).

Figure 1.1 Trends in the Prevalence (%) of Overweight and Obesity in School Children (7-18 years) based on the National Survey on Chinese Students' Constitution and Health during 1985-2010

(JI & CHEN, 2013; C Y Ji & Cheng, 2009)



Note: M=male, F=female

2.2 URBANIZATION, LIFESTYLES AND HEALTH

2.2.1 Definitions of Urbanization and Urbanicity

Urbanization refers to “change in size, density and heterogeneity of cities” (longitudinal), while urbanicity is “the impact of living in urban areas at a given point of time” (cross-sectional). Urbanization brings in both beneficial and deleterious effects to population health, and has become an international issue affecting both developed and developing countries.

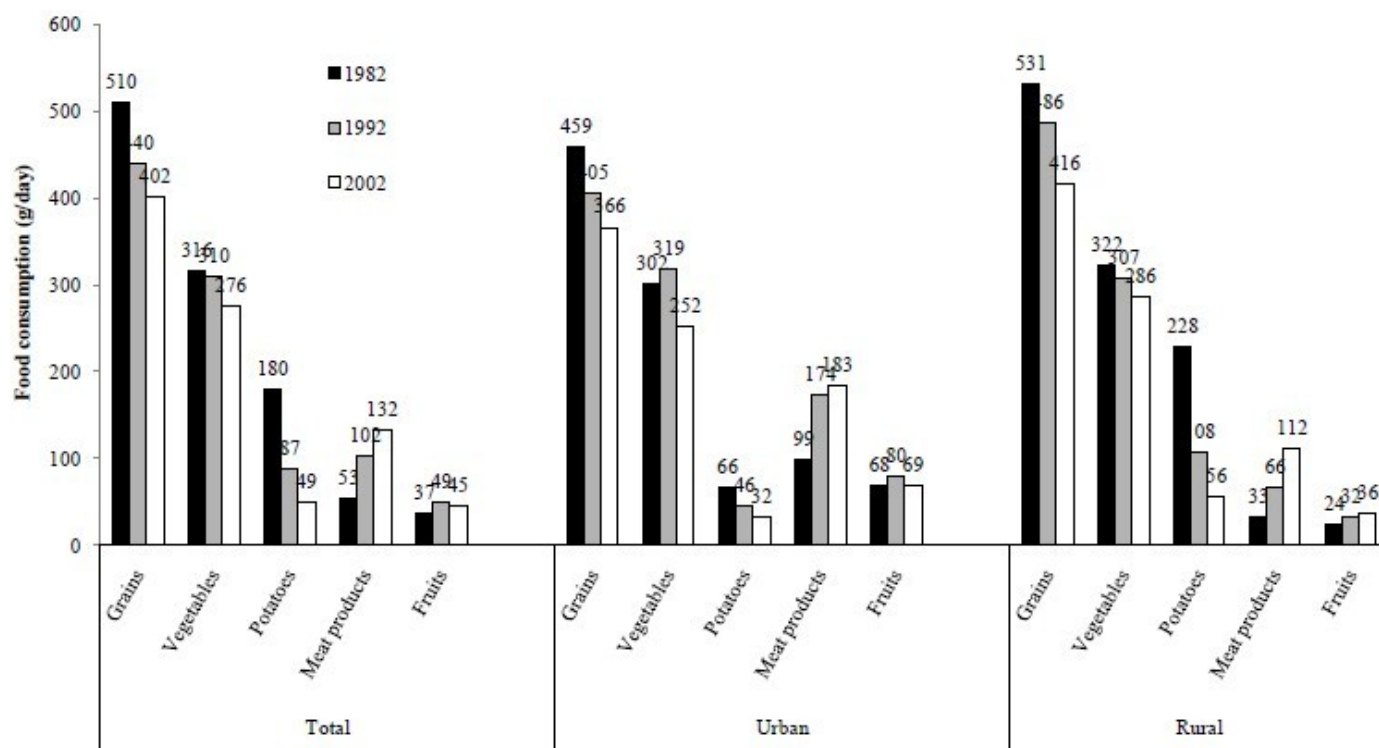
Though different definitions of urbanization exist, they share some core characteristics such as population size, density, heterogeneity and distance from other facilities, which are common in urban areas and can affect

urban health. Its impact on health can be grouped by the social environment, the physical environment and access to health and social services (Vlahov & Galea, 2002).

2.2.2 Impacts of Urbanization on Lifestyles and Health

Urbanization undoubtedly brings changes to individual lifestyles and population health, and this is more noteworthy in developing countries. In terms of diet, urban residents in developing countries are rapidly shifting from a low- fat traditional diet to a Westernized diet characterized by more animal meat products, refined food and higher fat intake as well as a more sedentary lifestyle and increased obesity(Z. Cui & Dibley, 2012; Zhai et al., 2014). An example is shown in **Figure 1.2** for changes in food consumption in China from 1982 to 2002, based on the Chinese National Nutrition and Health Survey (CNNHS) (Wang, Wu, Zhang, Yan, & Mi, 2011; Zhai et al., 2005). A recent study found that as a result of urbanization, from 1991 to 2011, the Chinese diet has shifted towards higher intakes of fats, added sugars, refined grains, edible oils, animal- source foods, snacks and food- away- from- home; while cooking methods have also shifted from steaming, baking and boiling to stir-frying (Zhai et al., 2014).

Figure 1.2 Changes in Food Consumption (g/day per Reference Man) in China based on the 1982, 1992 and 2002 China National Nutrition and Health Survey, by Urban-Rural Residence
(Wang et al., 2011; Zhai et al., 2005)



Urbanization is a potential contributor to obesity, as evidenced by the urban/rural disparity in terms of childhood obesity prevalence. Based on a survey in Beijing, 23.6% of children were either overweight or obese, which doubled the prevalence in other rural areas (13.6%) (Shan et al., 2010). Such differential levels of urbanicity lead to differences in the distribution of environments, which result in higher levels of physical inactivity, higher levels of fat and sodium intake, and lower levels of fruits and vegetable intakes among urban as compared to rural residents (Gu et al., 2005).

The cross-sectional distribution and temporal growth of childhood obesity rates also differs geographically nationwide. Data from CNSSCH showed that among school children from large coastal cities including Beijing, Shanghai, Tianjin, Shijiazhuang, Shenyang, Dalian, Jinan, Qingdao and Nanjing, 32.6% males and 19.1% females were either overweight or obese in 2010, which almost caught up with their counterparts in the United

States (JI & CHEN, 2013). On the other hand, the prevalence was only 8.2% in boys and 5.2% in girls among those living in the poor, Western, lower class or rural regions of China (JI & CHEN, 2013). This geographical distribution of childhood obesity is a result of the regional disparities in SES as urbanization proceeds, which leads to different levels of economic markets, life facilities as well as lifestyles (Ji & Cheng, 2008).

It also exhibited different temporal trends by urbanicity levels: the prevalence of overweight and obesity in the north costal upper SES cities increased the earliest and grew the fastest since the 1980s. Later the epidemic spread to other regions, firstly to other upper SES cities in the 1990s and later moved to coastal prosperous rural areas in the 2000s (Ji & Cheng, 2009).

2.2.3 China as a Case Study

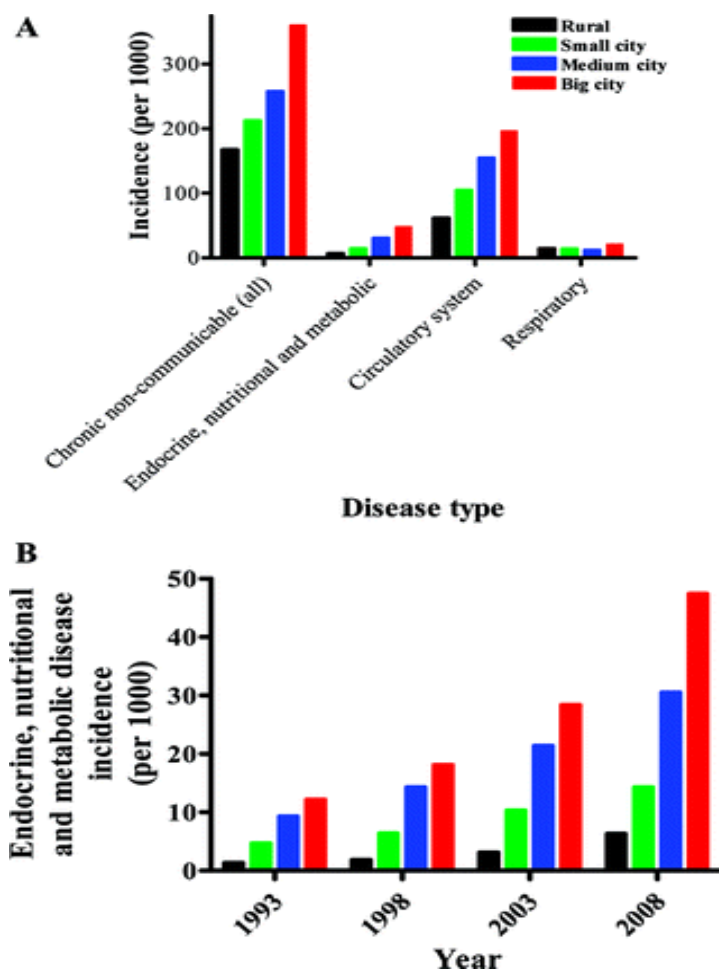
China is an ideal setting to study the impact of urbanization, for its rapid process of urbanization during the past three decades. The level of urbanization in China increased from 18% in 1978 to over 50% in 2014 (National Bureau of Statistics of China, 2014; Zhu, Ioannidis, Li, Jones, & Martin, 2011). Rapid urbanization in this country has led to boosted economic growth, increased family income and changes in labor distribution, which brought in vigorous shifts in the diet structure as well as physical activity (PA) patterns in its population (Adair, Gordon-Larsen, Du, Zhang, & Popkin, 2014; Samantha M. Attard et al., 2015)

Urbanization in China is positively associated with higher incidence of NCDs (**Figure 1.3**) and poor healthy (Van de Poel, O'Donnell, & Van Doorslaer, 2012; Zhu et al., 2011). Certain features of urbanization, including pollutions, modern lifestyles, and changing built environments increased the risks of certain NCDs (Zhu et al., 2011). The Coronary Heart Disease Model- China, a national simulation study projected a growth of cardiovascular disease incidence by more than one fold in urban areas, and a 27.0% to 45.6% increase in rural areas in China from 2010 to 2030, a result of the rural- to- urban migration due to urbanization (Chan et al., 2012).

Figure 1.3 Non-communicable disease incidence rates along a rural-urban gradient in China over the last 20 years.

- (A) Chronic disease incidence rates for 2008 for chronic non-communicable disease, endocrine, nutritional and metabolic disease, circulatory system disease, and respiratory disease;;**
- (B) Temporal changes in endocrine, nutritional, and metabolic disease incidence rates from 1993 to 2008.**

(Zhu et al., 2011)



As stated above, urbanization has radically changed the Chinese food systems and led to a Westernized diet. The mainstream Chinese diet has been moving from a primarily plant-based one to an animal-based one, with increased consumptions on food-away-from home and snacks (Cui & Dibley, 2012; Popkin, 2014; Wang et al., 2012; Zhai et al., 2005, 2014). Furthermore, the traditional cooking methods of baking, steaming and boiling are being replaced by stir-frying and thus increased edible oil consumption (Popkin, 2014; Zhai et al., 2014). Such

nutrition transition has also been observed in many other developing countries (Popkin, 2014; Popkin et al., 2012).

In addition to shifts to a Westernized diet, urbanization is linked to a more sedentary lifestyle. For example, researchers have found a decline in occupational, domestic as well as total PA levels in China from year 1991 to 2006. Such decline is a result of a changing occupation structure and less labor demand of jobs, as PA at work is the main contributor of PA for the Chinese population. This reduction comes along with some features of urbanization, especially with community economic conditions, availability of educational institutions, improved sanitation and housing infrastructures. Access to food markets is also strongly associated with declines in PA levels. Those community-level urbanization dimensions can explain 40 to 81% of the decline in total and occupational physical activity (Monda, Gordon-Larsen, Stevens, & Popkin, 2007; Ng, Norton, & Popkin, 2009).

The combination of a Westernized diet and a sedentary lifestyle undoubtedly leads to a higher incidence of overweight and obesity (Zhang, Zhao, & Chu, n.d.). Data from CHNS89-06 shows that women living in less urbanized communities at baseline and experienced a sharp increase in urbanization had significantly higher incidence of overweight/obesity, and the influence of urbanicity on overweight/obesity appeared to have a ceiling effect (which means that the influence is trivial when it reaches to a certain threshold) (Jones-Smith & Popkin, 2010).

Meanwhile, we need to acknowledge that urbanization also has beneficial effects on population health. A study investigated 286 cities across almost all provinces in China between year 1989 and 2009, and found a positive linear relationship between urbanization and green space coverage, which may facilitate walkability (Zhao et al., 2013).

2.2.4 Development of Urbanicity Scale in China

There are various ways to measure urbanization, which is complicated. Jones-Smith and Popkin (2010) developed a 12-item urbanicity scale based on the CHNS data. We modified the scale and used it in our study.

This scale models urbanicity as a continuum and demonstrates good measurement quality in terms of reliability, content, criterion and constructs validity. Its Cronbach's alpha ranges from 0.85 to 0.89 throughout the study waves and exhibits great criterion validity in distinguishing odds of overweight/obesity. Items in the scale include:

(1) Population density: total population of the community divided by community size, from official records;

(2) Economic activities: typical daily wage for ordinary male worker (reported by community official) and proportion of the population engaged in non- agricultural work;

(3) Traditional markets: distance to the market including three categories: (i) within the boundaries of the community; (ii) within the city but not in this community; (iii) not within the city/village/town; number of days of operation for eight different types of market (including food and fuel markets);

(4) Modern markets: number of supermarkets, cafes, internet cafes, indoor restaurants, outdoor fixed and mobile eateries, bakeries, ice cream parlors, FF restaurants, fruit and vegetables stands, bars within the community boundaries;

(5) Transportation infrastructure: most common types of road, distance to bus stop, and distance to train stop;

(6) Sanitation: proportion of households with treated water and proportion of households without excreta present outside the home;

(7) Communications: availability of a cinema, newspaper, postal service, telephone service, and proportion of households with a computer, proportion of households with a television, and proportion of households with a

cell phone;

(8) Housing: average number of days a week that electricity is available to the community, proportion of community with indoor tap water, proportion of community with flush toilets, and proportion of community that cooks with gas;

(9) Education: average education level among adults >21 years old;

(10) Diversity: variation in community education levels and variation in community income levels;

(11) Health infrastructure: number and type of health facilities in or nearby (≤ 12 km) the community and number of pharmacies in the community;

(12) Social services: provision of preschool for children under three, availability of commercial medical insurances, free medical insurance, and/or insurance for women and children.

2.3 WESTERN FAST FOOD (FF)

2.3.1 Expansion of the Fast Food Industry and Increased Western Fast Food Consumption

The Western FF industry has been proliferating during the past several decades. Taking McDonald's as an example, it served an average of 64 million customers per day worldwide, and its total revenues added up to \$24,075 million in 2010, an increase by more than one-fourth since 2005. In 2010, there were 32,737 McDonald's restaurants worldwide, with 14,027 in the US, 6,969 in Europe and 8,424 in Asia Pacific/Middle East/Africa. Just one decade ago, there were only 28,707 restaurants globally (McDonald's, 2000, 2010).

Along with urbanization, the Western FF industry has been expanding in China since 1987, when Kentucky

Fried Chicken (KFC) opened its first branch in Beijing. In the past decade, China's FF industry has been growing by about 10 to 20% annually (China Research and Intelligence, 2011). Our recent study based on 2,656 school-age children taking part in CHNS found that the proportion of children having consumed Western FF in the past three months increased from 18.5% in 2004 to 23.9% in 2009, and the increase was more prominent in adolescents, boys, and children from low- and medium-income families, rural areas, and East China (Xue, Wu, Wang, & Wang, 2016). The rapid growth of Western FF in this country is the result of changing lifestyles, which values efficiency and convenience. In addition, Chinese adolescents are attracted to FF out of curiosity and faddish (McGregor, 2003).

Due to its relatively higher price compared to traditional Chinese food, Western FF consumption is more common for children from high SES families. In addition, at present Western FF restaurants in China are still mainly located in urban areas. In general, people in urban areas have higher SES than those in rural areas in China. A survey conducted in Jiangsu province reported that almost 10% of boys from high SES families consumed hamburgers on a daily basis, while the prevalence was only 2.8% among boys from low SES families (Shi, Lien, Kumar, & Holmboe-Ottesen, 2005).

2.3.2 Mechanisms Linking Western Fast Food Consumption to Obesity

A systematic review of 16 studies found an unequivocal association between FF consumption and caloric intake, as well as with increased weight and prevalence obesity across different age and racial/ethnic groups in Europe and the United States (Rosenheck, 2008). Frequent visits to FF restaurants (1-2 times or more) predicted weight gain (by 0.65 ± 0.32 kg) as well as an increase in waist circumference (1.06 ± 0.41 cm) among middle-aged and older adults in the US (Li et al., 2009). Mexican American children were 1.2 times more likely to be overweight when their families most often dined at FF outlets (Duerksen et al., 2007). Similarly, children who frequently ate Western FF consumption were 50% more likely to be obese than those who did not in Beijing (Shan et al., 2010).

Researchers have provided several explanations for this well- documented association. First, FF meals are

usually energy dense, high in glycemic index and fat while low in fiber. Moreover, they are commonly consumed with sugar- sweetened beverages. FF consumption, mediated by energy density, could induce insulin hypersecretion and the development of insulin resistance, leading to obesity (Isganaitis & Lustig, 2005).

Compared to adults, children and young adolescents are more susceptible to the influence of high energy density as they have not fully developed sufficient cognitive capacities to recognize energy density in what they eat and thus control their appetite (Prentice & Jebb, 2003).

Despite the unequivocal evidence linking Western FF consumption to obesity, issues related to dietary assessment methods and confounding in those studies still exist. First of all, it was argued that a Food Frequency Questionnaire (FFQ) performs better in capturing an individual's long- term dietary patterns than 24-hour diet records or other dietary measurements. Second, portion size and actual item consumed should be reported in addition to a single question asking the frequency of FF consumption. While the results were unequivocal, more studies are needed to examine those associations in subgroups such as children and adolescents, and consider the effect of advertising and branding (Rosenheck, 2008).

2.3.3 Study on Western Fast Food Consumption and Childhood Obesity in China

Despite growing evidence collected from developed countries, whether the growing Western FF industry has contributed to the growing obesity epidemic in China needs close scrutiny. The available studies including ours are limited and have limitations, e.g., most are cross-sectional studies. The preliminary findings including ours showed conflicting results in terms of the association between Western FF consumption and child obesity (Hsu et al., 2011; Shan et al., 2010; Xue et al., 2016). For example, one cross- sectional study conducted in Beijing reported that consuming three or more times Western FF per week increased the odds of obesity by 50% as compared to those consuming less than once per week among 2- 18 years children in Beijing (Shan et al., 2010). In contrast, another cross -sectional study investigating 9,023 adolescent from seven cities in China reported a 7% reduced odds of being overweight with frequent FF intake (Hsu, 2011). Our recent study based on the CHNS data, conducted both cross- sectional and longitudinal analyses and neither found a clear link

between Western FF consumption and overweight/obesity risks or BMI z- score (Xue et al., 2016).

2.4 FOOD ENVIRONMENT

2.4.1 Definition and Categorization of Food Environment

Food environment is a set of places where people can obtain and consume food, including food stores, restaurants, schools and workplaces. The ANGELO (ANalysis Grid for Elements Linked to Obesity) framework (refer to **Table 2.1** for an example) dissects the environment into a 2*4 grid, as a multiplication of environmental size (micro and macro) and environmental type: physical (what is available), economic (what are the costs), political (what are the rules) and socio- cultural (what are the attitudes and beliefs) (Mooney, Jepson, Frank, & Geddes, 2015). In this way, different environments can be put into this grid for further interpretation.

Table 2.1 Example of The ANGELO Framework (Swinburn et al., 1999)

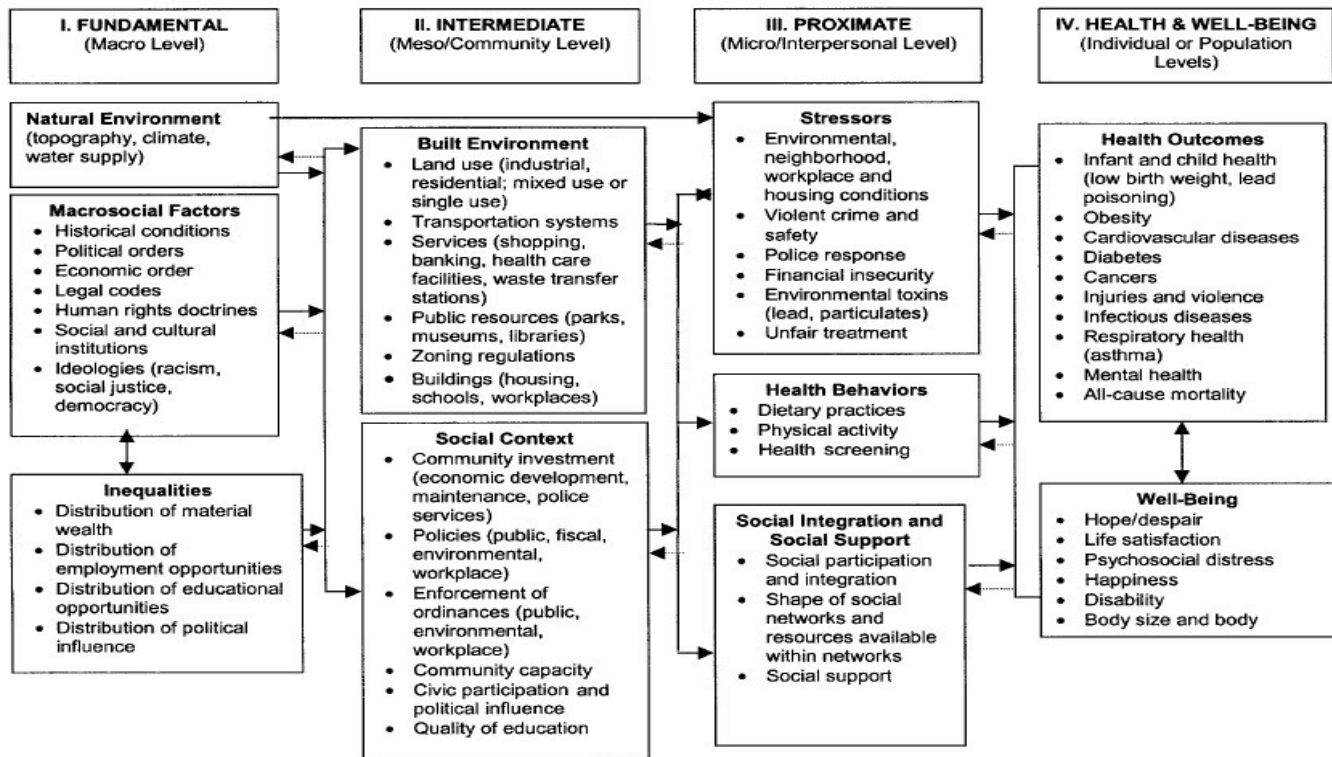
Size	Type			
	Physical (Food and PA)	Economic (Food and PA)	Political (Food and PA)	Sociocultural (Food and PA)
Micro (settings)				
Festivities				Cultural importance of high-fat foods
Neighborhoods	Recreation and sports facilities Safe walking paths			
Schools	Canteens serving local food		Policies on physical education Promotion of traditional activities, e.g., dancing	
Homes	Home gardens			
Churches				Church leaders as role models
Markets	Availability of local food (especially fish and vegetables)			
Macro (sectors)				
Transport	Availability of buses and bus stops			
Health regulatory system			Policies and standards on imported food quality/ labeling	

Note. PA, physical activity.

In addition to the ANGELO framework, the Social Determinants of Health and Environmental Health Promotion Model (**Figure 2.1**) also tried to group the food environment and examine its influence on health. In this model, the fundamental (macro-level) environment serves as the background for individual health and well-being, while the intermediate (meso/community-level) factors such as the built environment and social context plays as the fore-ground. Health behaviors and social support are the proximate factors that lead to health outcomes and individual well-being (Northridge, Sclar, & Biswas, 2003).

Figure 2.1 the Social Determinants of Health and Environmental Health Promotion Model

(Northridge et al., 2003)



2.4.2 Mechanisms for the Influence of Food Environment on Individual Behaviors and Weight Outcomes

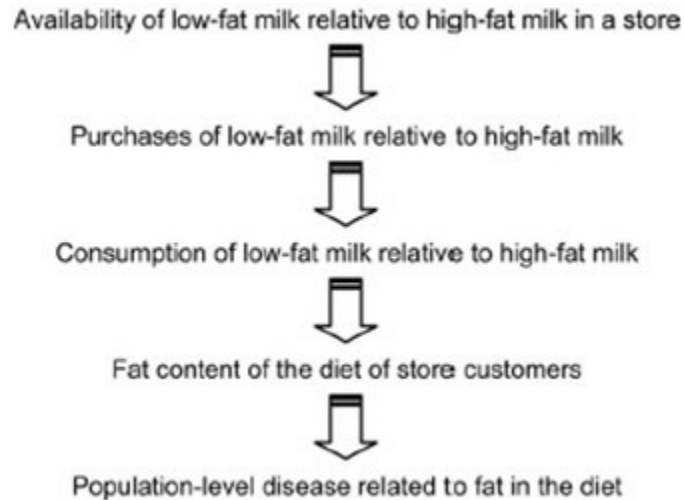
Many explanations exist in trying to understand how the food environments influence individual lifestyles, weight status and weight- related health outcomes.

On one hand, some researchers treat the food environment as an effect modifier. A longitudinal study in middle- aged and older adults substantiated the idea that FF restaurants density and community walkability acted as effect modifiers between individual consumption of FF and their weight and waist circumference (Li et al., 2009).

On the other hand, food environment is regarded as a cause of individual consumption and subsequent health outcomes. Some researchers postulate a model linking some attributes of the food environment to people's actual consumption and subsequent diseases. In this model, food availability leads to purchasing, consumption and subsequent health outcomes (Lytle, 2009).

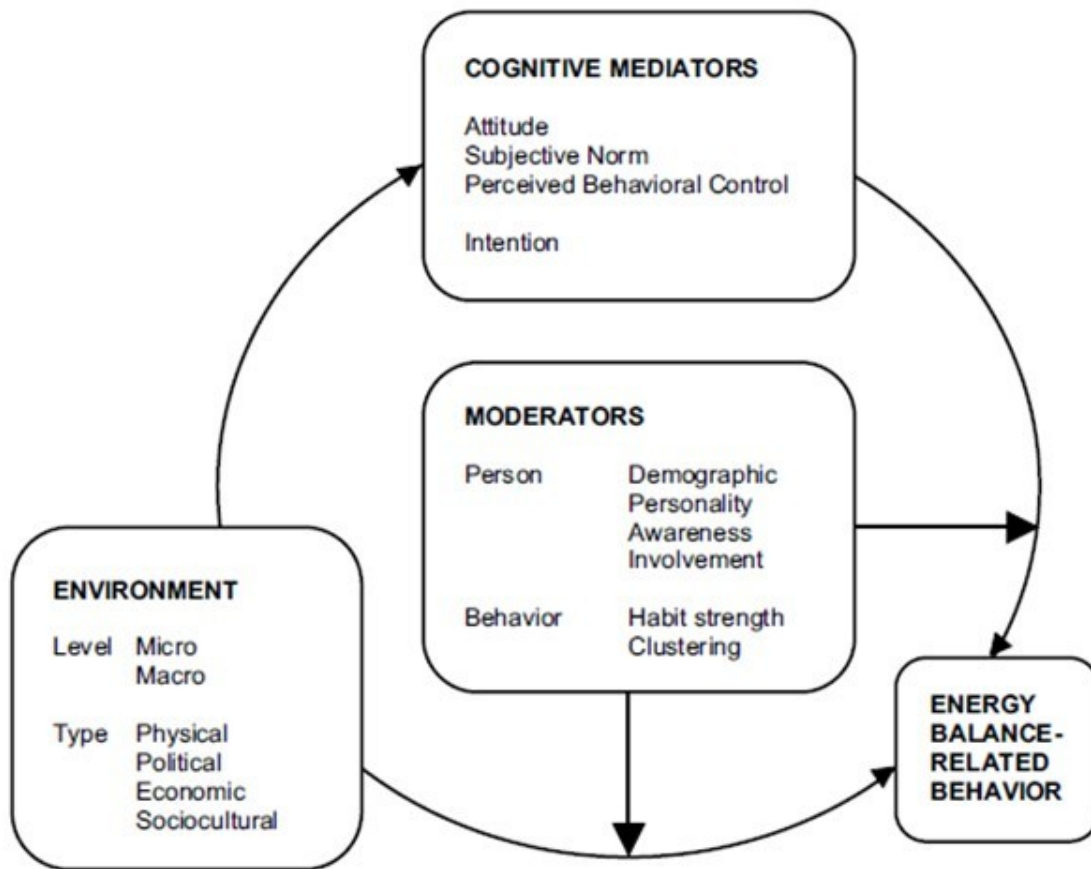
Figure 2.2 Example of Lytle's Model Linking Food Environment to Population-level Disease

(Lytle, 2009)



In addition to Lytle's direct influence assumption, the EnRG framework (Environmental Research framework for weight Gain prevention, see **Figure 2.3**) postulates a dual-process model: the environment can indirectly influence energy balance-related behaviors through cognitive mediators including attitudes, subjective norms and perceived behavioral control (consciously), and also contribute to these behaviors directly, without individual awareness (unconsciously). A group of personal factors including demographic, personality, awareness and involvement as well as behavioral factors like habit strength and clustering of behaviors moderate the relationship both in the indirect and direct pathways (Kremers et al., 2006).

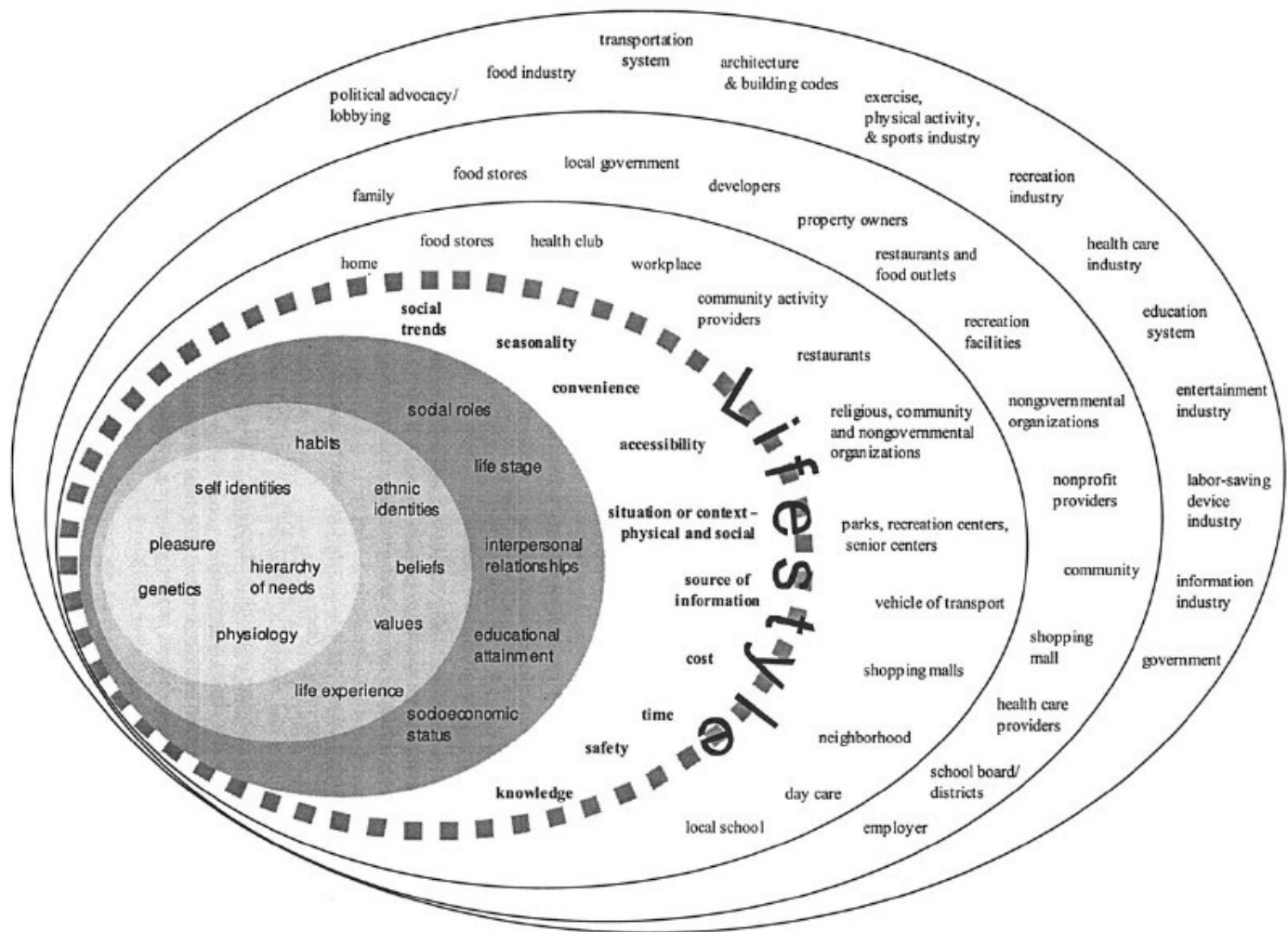
Figure 2.3 The Environmental Research Framework for Weight Gain Prevention (EnRG) Framework
(Kremers et al., 2006)



Another framework stemming from the socio-ecologic model identified three dimensions of environmental and societal influences: (1) behavior settings or micro- environment where the actual behavior takes place (e.g. home); (2) proximal leverage points that manipulate behavior settings (e.g. neighborhood food stores); and (3) distal leverage points that influence behavior settings indirectly (e.g. the food industry), as shown in **Figure 2.4**.

Figure 2.4 Framework for Determinants of Physical Activity and Eating Behaviors

(Booth et al., 2001)



2.4.3 Physical Environment: Local Food Environment and Obesity

Due to failures in individual- level interventions, researchers turned to explore the influence of environmental factors on diet quality and weight status (McKinnon, Reedy, Morrisette, Lytle, & Yaroch, 2009). Built environment contributes to obesity through three types of environment: food environment, land use/transportation environment and physical activity environment. Those built environments provide contextual factors for people's health behaviors by influencing residents' diet and PA patterns (Feng, Glass, Curriero, Stewart, & Schwartz, 2010). Consequently, studies on the geographical distribution of food service

establishments (e.g. FF outlets and full-service restaurants) and food retail places (e.g. supermarkets, grocery stores and farmers' markets) have been expanding since the late 1990s (Gibson, 2010).

The food environment “involves the sources of energy and nutrients and the circumstances surrounding their procurement and consumption”(Holsten, 2009). Following the ANGELO framework discussed above (Swinburn et al., 1999), we focused on the physical, economic and socio-cultural environment in this study.

First of all, the local food environment as the physical food environment, which is set within the community, serves as the context for people's dietary patterns and thus influences body weight. The common components under investigation include two aspects: food retail places (e.g. supermarkets) and food service places (e.g. restaurants) (Gibson, 2010).

We have identified six systematic reviews looking into the relationship between the built environment and obesity in the past ten years (Feng et al., 2010; Galvez, Pearl, & Yen, 2010; Holsten, 2009; Papas et al., 2007; Rahman, Cushing, & Jackson, 2011; SALLIS & GLANZ, 2009). Of the four reviews, three concluded with a linkage between some aspects of the built environment and obesity. One reviewed studies conducted between 1966 and 2007, and found that over four fifths of the finally included 20 articles reported significant associations between some features of the built environment and obesity (Papas et al., 2007). Another review summarized recent reviews and empirical studies and concluded that those living in communities with better walkability and accessibility to healthy food tended to be more physically active and eating a more healthy diet, and thus being less likely to become obese (SALLIS & GLANZ, 2009). However, the other two reviews, with one including a total of 63 relevant papers and the other seven studies, did not reach a clear conclusion (Feng et al., 2010; Holsten, 2009). The third study conducted a multidisciplinary literature review and pointed out that children's built environment determines their access to healthful foods and physical activity, and thus risk of overweight/obesity are positively associated with their access to convenience stores, and negatively associated with access to supermarkets and farmers' markets(Rahman et al., 2011).

Despite conflicting findings, available research suggests some key research gaps in study design and measurement, as well as difficulties in drawing a conclusion due to heterogeneity across studies (Feng et al.,

2010; Galvez et al., 2010; Holsten, 2009; Papas et al., 2007; SALLIS & GLANZ, 2009).

2.4.3.1 Food Retail Places

Higher supermarket accessibility is generally found to be associated with more fruits and vegetable consumption and lower BMI, while higher grocery stores accessibility is found to be associated with higher BMI and increased overweight rate among US adolescents (Moore, Diez Roux, Nettleton, & Jacobs, 2008; Powell, Auld, Chaloupka, O'Malley, & Johnston, 2007; Powell, Han, & Chaloupka, 2010).

2.4.3.2 Food Service Establishments (fast food outlets)

Fast food availability and individual diet. Studies investigating the link between FF availability and diet yielded contradictory results. Some evidence showed that FF availability was associated with lower fruit and vegetable intake (Fraser et al., 2010); while one study in New Zealand showed that residents with limited access to franchised FF restaurants were more likely to consume vegetables but being overweight (Pearce, Hiscock, Blakely, & Witten, 2009). Another study on 8,226 children and 5,236 adolescents from the 2005 and 2007 California Health Interview Survey did not find any robust relationship between food environments and food consumption (An & Sturm, 2012).

Fast food availability and weight status. FF outlets, as a notorious component of the food service establishments, have been studied by numerous researchers. However, conflicting results have been found with regard to the association between FF availability and resident obesity, maybe because the majority of these studies are cross-sectional in nature (Fleischhacker, Evenson, Rodriguez, & Ammerman, 2011; Fraser, Edwards, Cade, & Clarke, 2010). Some researchers have found a positive association between the prevalence of FF restaurants and obesity on a state-level analysis (Maddock, 2004), while some found a negative association (Crawford et al., 2008) or no association between proximity to FF outlets and BMI/obesity risks (Jeffery, Baxter, McGuire, & Linde, 2006; Zick et al., 2009), between FF outlet density and BMI/obesity risk (Jeffery et al., 2006; Rundle et al., 2009).

Such study on children is relatively scarce. Some studies did not find any association either between the availability of FF restaurants with youth BMI (Powell et al., 2010), or between child overweight and proximity to FF outlets from a child's home (Burdette & Whitaker, 2004). Another study reported that the availability of FF restaurants within one tenth of a mile from school increased the prevalence of obesity by at least 5.2% among 9th graders (Currie, DellaVigna, Moretti, & Pathania, 2009).

Fast food availability and NCDs. When looking into the relationship between FF restaurants and NCDs, conflicting results remained. Some found no association in a metropolitan population in Montreal, Canada (Daniel, Paquet, Auger, Zang, & Kestens, 2010), while another study also in Canada reported increased mortality and acute coronary hospitalizations with rise on per capita rate of FF outlets (Alter & Eny, 2005).

Some studies argue that it is indeed not a specific type of food outlet, but the numbers and variety of food outlets matter. An observational study in US followed children from fifth to eighth grade and suggested that it was not a specific food outlet increased or lowered children's BMI (e.g., better access to FF outlets), but the variety of food outlets increased children's BMI (Shier, An, & Sturm, 2012).

2.4.3.3 Community Disadvantage/Deprivation as Effect Modifiers

The impact of local food environment on individual BMI and/or risk of being obese differ by community SES. This may stem from community deprivation, such as differential levels of ownership of private vehicles to access food, differential levels of affordability to dine in full- service restaurants and so on (Zick et al., 2009). This finding corresponds to a model with regard to the differential impact of environmental factors on explaining eating behaviors based on levels of area restriction. The model assumes a greater impact of environment factors (while a lower proportion of influence for individual and social factors) in high- restricted places (e.g. in low- income communities) and a weaker impact of environmental factors and greater impact of individual and social factors in low- restricted places (e.g. in non-low income communities) (Lytle, 2009).

In addition to community- level factors, there are also individual variations in response to the obesogenic environment. For example, individual variations in impulsiveness and sensitivity to reward determine an

individual's susceptibility to environmental cues of eating (Hetherington, 2007). In terms of age, young children have biased view of food advertising; while older children and adolescents do not try to counter- argue the undue influence of food marketing (Harris & Graff, 2011). Males and females also responded differently to the environment, with males being more responsive to PA interventions. Such difference is a result of a myriad of biological, social (e.g. gendered food, body image) and behavioral factors (e.g. PA levels) (Sweeting, 2008). Though many studies have been conducted to investigate individual differences in obesogenic behaviors and prevalence of obesity, only a few have looked into individual variations in vulnerability to obesogenic environment. This study tried to answer these questions by stratified analysis.

2.4.4 Economic Environment: Food Price and Obesity

Food price is believed to affect people's food intake, diet quality and obesity risk. In the US, higher FF prices are found to be related to higher fruit and vegetable consumption (Powell et al., 2010), higher overall diet quality, higher fiber and lower saturated fat intake (Beydoun, Powell, & Wang, 2008) as well as lower BMI and decreased risk of obesity (Chou, Grossman, & Saffer, 2004; Powell et al., 2010). Results from CHNS found that a reduction in oil prices can change dietary compositions (Ng, Zhai, & Popkin, 2008) and increase the percentage of people with high body fat without significant changes in body weight among Chinese adults (Lu & Goldman, 2010). A 10% increase in the price of the cheapest edible oil led to 24.2% decrease in rice consumption, and 12.4% increase in flour consumption, and this pricing effect was more consequential among the poor (Ng et al., 2008).

Research on the effect of fruit and vegetable prices on diet and weight was limited. Results from our research team based on the USDA Continuing Survey of Food Intakes by Individuals (CSFII 1994-96) show that the price of fruits and vegetables was negatively associated with overall diet quality, and was positively associated with cholesterol and sodium intakes as well as BMI among 7,331 adults (Beydoun et al., 2008).

Despite evidence for the pricing effect of a specific food, it is necessary to bear in mind that price change in one food might have impact on the demand for other foods and relevant nutrients. For example, an increase in

edible oil prices not only resulted in decreased edible oil consumption, but also led to decreased rice consumption (as supplement to edible oil) and increased flour consumption (as substitutes of rice) in China (Ng et al., 2008).

Changes in food prices in China are believed to be mostly driven by the supply side and upon governmental decisions rather than by the demand side (Ng et al., 2008). As a result, governmental regulations on food prices are powerful leverages to regulate food consumption and curb the obesity epidemic while raising revenues. Such measures have been undertaken in many developed countries in terms of food taxes and food subsidies (Caraher & Cowburn, 2005). Many countries in Europe and North America have started or are planning to impose “fat tax” (Caraher & Cowburn, 2005). Food taxation has small but incremental effect on food purchasing and consumption. Results from a systematic review found the price elasticity for soft drinks was -1.0 to -0.8, which means a 10% increase in the price of soft drink prices would reduce its consumption by 8% to 10% (Andreyeva, Long, & Brownell, 2010; Brownell et al., 2009). A systematic review concluded that lower weight outcomes are linked to more expensive FF, cheaper fruit and vegetables, especially among the low-SES populations in US (LM Powell, Chriqui, Khan, Wada, & Chaloupka, 2013).

Changes in Western FF prices in China are driven by similar factors as those for other food. For example, prices in KFC had risen three times in China due to price rise in ingredients, especially in chicken (People's Daily Online, 2011). Meanwhile, there are also small region-to-region variations in terms of FF prices because of their franchised operation practice.

2.4.5 Socio- cultural Environment: Community Norms and Obesity

In addition to the built environment and food prices, socio-cultural factors also contribute to Western FF consumption and childhood obesity, in terms of social norms, food preferences and brand loyalty. The FF industry has been successful in marketing its products to children through brand loyalty. Children aged 4 to 8 years could identify FF restaurant logos. McDonald's and Burger King's were recognized at 89% and 86%,

respectively. Moreover, the recognition rates for FF as compared to other food were higher among overweight and obese children. Children's exposure to FF commercials plays a role in their food preferences and might influence their food negotiation and household food purchasing behaviors (Arredondo, Castaneda, Elder, Slymen, & Dozier, 2009). Though studies did not find any link between FF marketing and parental attitudes toward FF, it still suggests a potential intergenerational link for brand equity of FF (Grier, Mensinger, Huang, Kumanyika, & Stettler, 2007; Moore, Wilkie, & Lutz, 2002).

Urbanicity plays a part in shaping the norms of FF consumption. Not only does urban adolescents consume more Western FF than their rural counterparts, but they showed stronger preferences for it as well (Shi et al., 2005). Our community-level analyses showed that urbanicity is positively associated with stronger norms of nutrition knowledge, as well as FF preferences and consumption (Wu et al., 2016).

2.5 RESEARCH GAPS IN THE LITERATURE

2.5.1 Measurement of Urbanization/Urbanicity

Measuring urbanicity is a critical, but challenging step for urban health researchers. Urbanicity is defined by the transformations brought about by changes in population size, density, heterogeneity, and distances from other population centers (Vlahov & Galea, 2002).

First, the traditional dichotomous urban/rural distinction cannot fully capture the rapid urbanization process taking place in China and there are substantial heterogeneity within the administrative urban/rural categories (Dahly & Adair, 2007; Van de Poel, O'Donnell, & Van Doorslaer, 2009). Instead of a dichotomous classification, urbanicity can be seen as a continuum: from low to high levels of urbanicity to capture the change in urbanization across time and space (Van de Poel et al., 2009), assess dose-response relationships for causal inference, and serves as a better predictor in regression models (Dahly & Adair, 2007).

Second, instead of being a single dimension, urbanicity is a latent variable that results in diverse patterns, such as changes in population size, population density, the built environment, and so on (Dahly & Adair, 2007).

Furthermore, areas with the same urbanicity index score may be different in some sub-dimensions of urbanicity. It is important to keep this in mind while avoiding simply putting all the sub-dimensions in one equation and facing with multicollinearity (Dahly & Adair, 2007).

2.5.2 Impact of Fast Food Availability on Obesity Risks

The inconsistent finding with respect to whether FF outlets have impact on obesity may originate from several issues. First, the majority of FF studies were based on a cross-sectional design. A longitudinal design can do a better job in capturing the impact of changes in the food environment (e.g. open-up or closure of FF restaurants) and the duration of exposure have on individual weight (Fleischhacker et al., 2011; Fraser et al., 2010).

Second, there is a mixed use of environment metrics, spatial scale and definitions of place, making it difficult to compare across studies. Metrics of the food environment vary between measures of density, diversity and proximity to food establishments (Feng et al., 2010). Metrics used in FF accessibility studies included density, proximity, count and ratio (Fleischhacker et al., 2011). Besides, spatial scales used in previous studies range from small units like census block groups, census tracts, zip code tabulation area (ZCTA) to larger units like counties and states. The best criterion to use is that the geographic units utilized to define the food environment should best approximate people's shopping and dining areas, which favors a smaller geographic unit (Zick et al., 2009) and thus can better capture environmental effects on individual body weight (Feng et al., 2010). However, most of the time the availability of data restricts researchers to operationalize access to the food environment. Finally, the definition of place used in previous studies include either administrative boundaries (e.g. census block group) or individual buffers (e.g. within 0.5 kilometer of one's home), making it even more difficult to compare between studies (Morland, Diez Roux, & Wing, 2006).

Third, the information on FF stores was mostly gathered from the internet, government or private sources, and was subject to errors. Cross-validation and ground-truthing is needed to correctly identify and classify FF

outlets (Fleischhacker et al., 2011)

Fourth, the definition of FF is usually inconsistent across studies (Fleischhacker et al., 2011). Sometimes researchers used a narrow definition of FF and thus underestimated the actual FF consumption. In addition to including the major FF franchises, other outlets which also sell FF must be taken into account, as they also contribute to FF consumption. Furthermore, exploring what type of FF (unhealthy vs. healthy alternatives) is actually consumed might better inform on diet quality and energy intake (Fraser et al., 2010).

Fifth, there is a need to control for other food sources where people can get food, such as supermarkets, grocery stores, convenience stores and so on (Fraser et al., 2010; Pearce et al., 2009). Focusing solely on limited aspects of the local food environment would yield unreliable findings, as it ignores the potential clustering of healthy and/or unhealthy food choices and its complex impact on people's dietary patterns (Zick et al., 2009).

Sixth, the proximity of FF outlets to residential places may not be a good indicator of fast food exposure, as FF consumption occurs mostly at lunch, when people under study are either at work (for adults) or at school (for school children) (Lopez, 2007).

Seventh, there has been controversy on whether to report the actual or perceived food environments. The actual and perceived food environments are two correlated but somehow different constructs, as indicated by the positive but not high correlations between supermarket density measures and residents' reports of availability (Moore et al., 2008). Lytle tried to answer this question in his conceptual paper and stated that it might be insufficient to just look into the objective environment. We need to understand how the environment gets into the body, provided that people's perceptions of availability and price were associated with their reported food purchases, while those documented through the store audits were not (Lytle, 2009).

Eighth, endogeneity issues arise when personal preference for where to live both influences people's behaviors as well as their living environment. However, the problem is minimal in China as the home registry system (hukou) limits mobility and minimizes self-selection, at least in previous years where migration to cities were not so widespread in China (Ng et al., 2009).

Ninth, there has been less evidence in children compared to that among adults. Though findings using

multiple cross-sectional data from the Monitoring the Future Surveys demonstrated a positive link between adolescent BMI and overweight and convenience stores availability, and a negative one with supermarkets availability (Powell et al., 2007), the body of literature is still small and thus needs more studies on this population (Holsten, 2009).

Finally, while FF outlets and other convenience stores in the community may impose negative influence on people's health, they also provide opportunities for energy expenditure if residents choose to walk or bike to those places. As a result, the net impacts of FF outlets should be taken into consideration (Zick et al., 2009).

2.5.3 Impact of Fast Food Consumption on Obesity Risk

Inconsistent findings have been reported regarding the association between FF consumption and obesity risk. Most of the studies were cross-sectional and from developed countries like the U.S., and few focused on children in developing countries and using longitudinal data.

2.6 DISTINCTIVE CHARACTERISTICS IN CHINA REGARDING THIS STUDY

While most of the studies on food environments focused on the Western societies such as the United States, New Zealand, Canada and the United Kingdom, it is critical to delve into countries with different dietary cultures (Fraser et al., 2010). Country to country variation with regard to environmental influence is tremendous. For example, compared to findings from other developed countries, findings related to the influence of community environmental factors on diet and obesity was more consistent and prominent in the United States, suggesting that Americans were more susceptible to the community-level contextual exposures. This may be a result of the more pronounced racial and SES segregation, and less regulations to compensate for it in US (Cummins & Macintyre, 2006).

From the epigenetic viewpoint, compared to people from developed countries, those living in developing

countries are new-comers to the Western lifestyles and are more susceptible to the adverse outcomes of obesity such as metabolic risks and insulin resistance. This stems from their long-term endurance of the so-called “thrifty genotype” (Neel, 1962) and are consequently less adaptable to the relatively new epidemic (López-Jaramillo et al., 2008). Moreover, some disproportionate fetal growth due to under-nutrition in middle or late gestation periods (which was very common in China three decades ago) would increase fetus’ risk of having coronary heart disease later in life, as illustrated by the “fetal origins hypothesis” (Barker, 1995).

What else makes China differ from other countries? First, contrary to the findings of more FF outlets in more deprived areas in developed countries, FF chains in China are predominantly clustered in cities rather than in rural areas (Popkin, 2008). This holds the theory of deprivation amplification untrue. In addition, family wealth and parental education was found to be positively associated with adolescent overweight and obesity in China, an inverse relationship as shown in the developed world (Hsu, 2011; Li, Dibley, Sibbritt, & Yan, 2007).

Second, the prices of healthy traditional food are relatively low in China, as compared to those in the developed countries (Gao, Griffiths, & Chan, 2008). On the contrary, the price of Western FF is relatively higher than some traditional healthy food. It would be worthwhile to see how changes in food prices alter FF consumption.

Third, social norms play an important role in Western FF consumption in China, especially among adolescents (McGregor, 2003). By exploring how children and their parents perceive FF and its health consequences would help researchers better understand the growth of FF industry and children’s FF consumption in China.

Such norms were partially pushed by the FF industry, who has been marketing aggressively to the Chinese population. Advertisement marketing of the two major Western FF brands in China, McDonald’s and KFC, specifically targets children, young people and families and rates themselves as serving a healthy, balanced and sanitary diet (Yu & Zhang, 2009). Cross-cultural comparisons between 395 college student in US and 410 college students in China found that the Chinese were more likely to rate FF served in KFC as healthy, well-balanced and made from fresh ingredients than their American counterparts, which is a result of both

national differences as well as different marketing strategies across these two countries (Witkowski, Ma, & Zheng, 2003).

2.7 SIGNIFICANCE

Recently the WHO has been calling governments worldwide to take timely actions to help end the childhood obesity global epidemic. Childhood obesity is endangering the Chinese population, a previous role model in terms of dietary intakes and low prevalence of obesity. The rapid urbanization process in China may bring in changes in the environment and lifestyles, and contributes to the rising rates of childhood obesity (Heikkila, 2007; Jones-Smith & Popkin, 2010; Monda et al., 2007; Popkin, 1999). This study aims to understand the impact of rapid urbanization on Western FF consumption and childhood obesity through three different types of food environment.

2.7.1 Theoretical Contributions

Though studies on the built environment have been proliferated since the 1990s, there are limited studies focusing on children as the subject of interest. Even for studies on children, researchers are more interested in the developed world, with only a few paid attention to those rapidly urbanized, developing countries. China would be a good example to test the influence of urbanization, for its rapid gross domestic product (GDP) growth, large population base, and relatively long dietary traditions. This study can facilitate our understandings on the impact of urbanization in a large developing country.

Investigating three dimensions of the food environment in one study can contribute to our understanding of the food environment. Previous studies usually focus on the built environment, or the socio-environment, without taking into account different aspects of the food environment. This study will add breadth to the field on food environment.

2.7.2 Contributions to Policy & Interventions

Understanding the association between urbanization, food environment, Western FF consumption and children's weight status can guide public health researchers and practitioners to minimize the adverse effects brought about by the fast economic development. For example, based on evidence from observational and prevention studies, an action guide was developed by the Community Anti-Drug Coalitions of America (CADCA) in partnership with the Center on Alcohol Marketing and Youth (CAMY) at the Johns Hopkins Bloomberg School of Public Health to advocate for reducing alcohol density as an effective strategy to fight against alcohol-related problems (Strategizer 55—Regulating Alcohol Outlet Density: An Action Guide, 2011).

Future researchers can develop a similar action guide based on findings from this study, and reduce the adverse impact of rapid urbanization on people's food consumption and health. Findings from this study may assist policy makers in making regulations on urban planning (e.g. limiting the density of FF restaurants in communities with more children), food marketing (e.g. censoring marketing of FF to young children), and food pricing (e.g. increasing the price of FF to discourage consumption). These may play a promising role in curbing the rising obesity epidemic in China. What learned in China could also help shed light for other countries' efforts to fight obesity.

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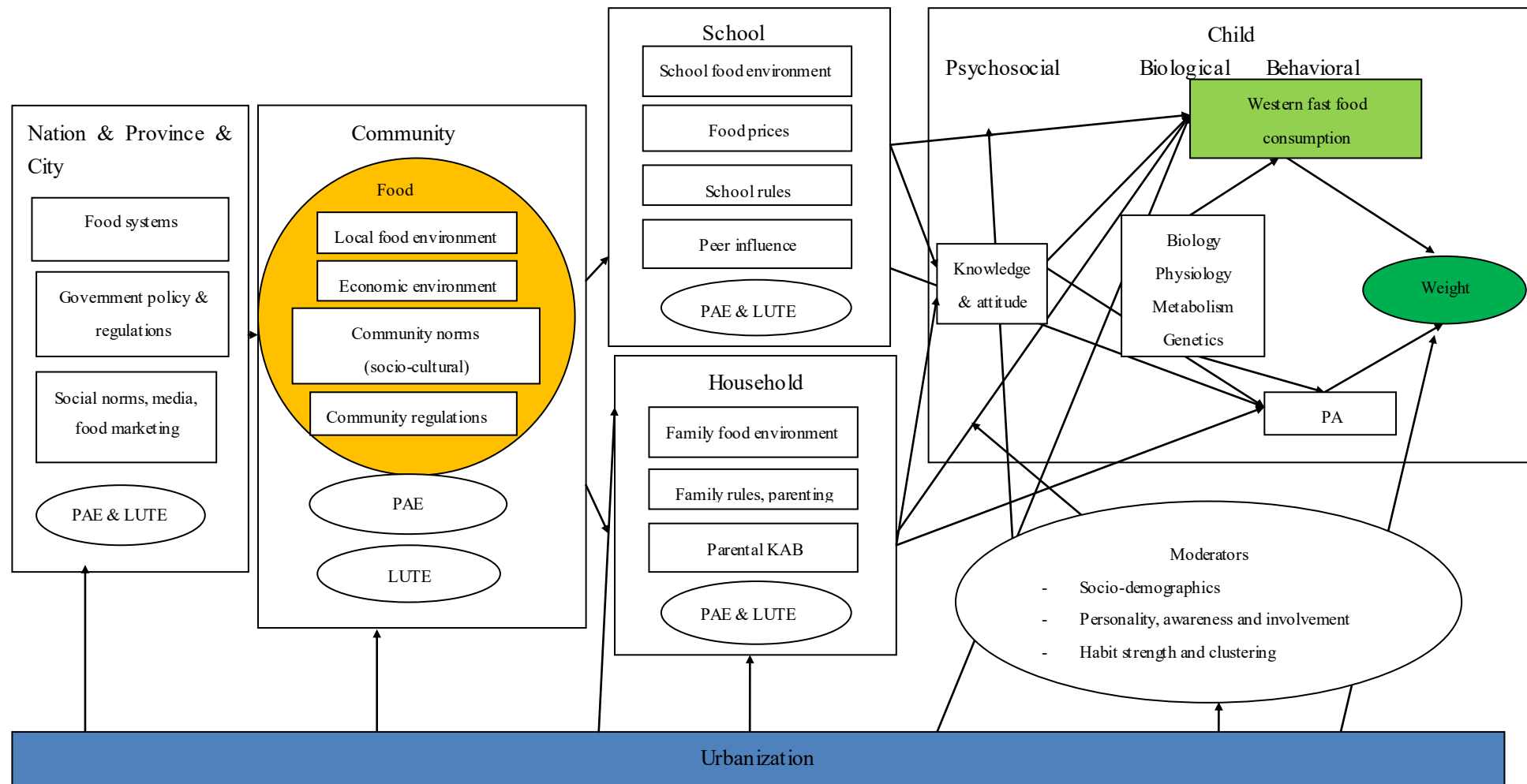
CHAPTER 3: STUDY DESIGN AND METHODS

3.1 CONCEPTUAL FRAMEWORK

A conceptual framework was developed for this study (**Figure 3.1**) based on the EnRG framework (Kremers et al., 2006), the ANGELO framework (Swinburn et al., 1999), the Social Determinants of Health and Environmental Health Promotion model (Northridge et al., 2003), the Framework for Determinants of Physical Activity and Eating Behaviors (Booth et al., 2001) and Valahov and Galea's urban health framework. There are four levels of influence on individual outcomes, including influence from location (nation, province and city), community, school, and the individual household. Within each level, environments are divided into the food environment, the PA environment and the land use/transportation environment, each of which has a direct influence on diet and PA as well as an indirect one through influencing the child's knowledge and attitudes. Overall, urbanization can influence all levels of environments, as well as individual-level variables.

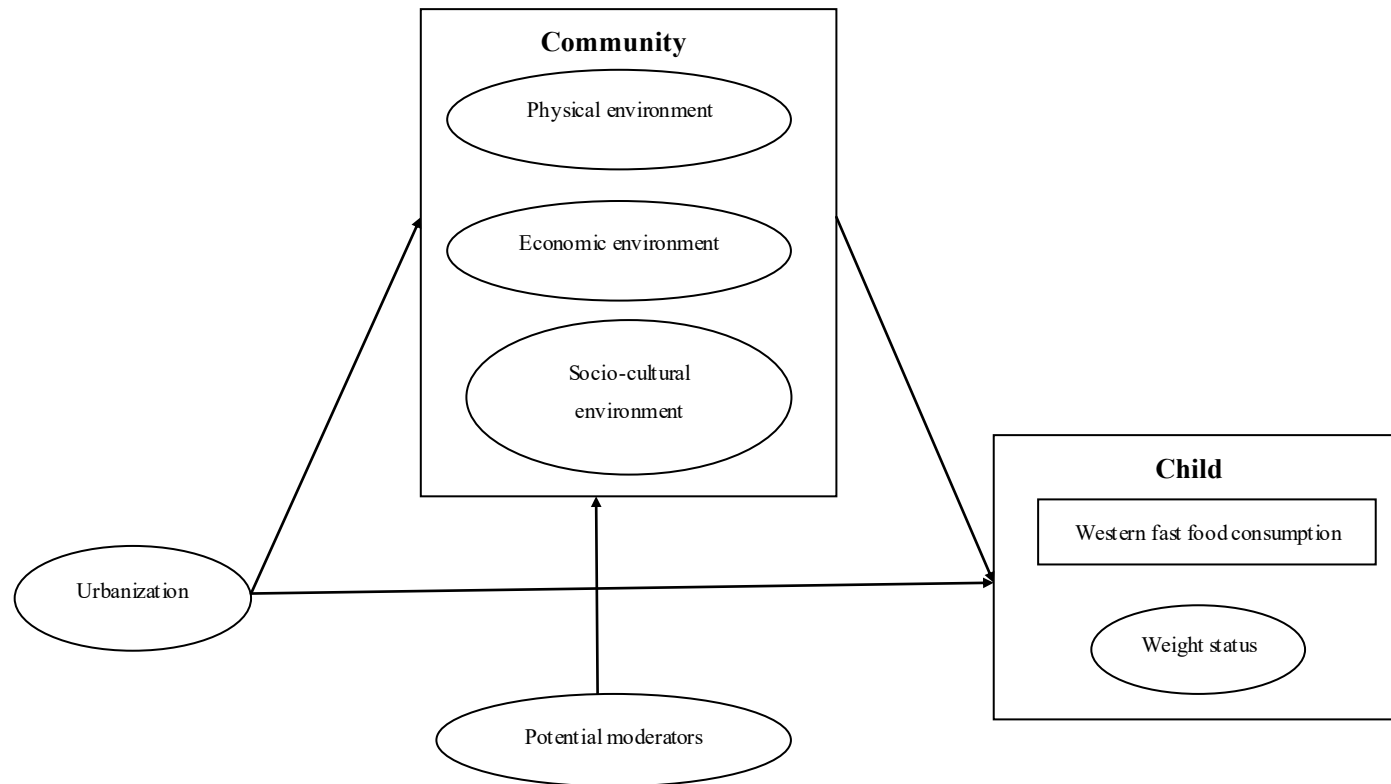
An analysis model is shown in **Figure 3.2** to facilitate understanding of the construct of this study and its analytic procedures. Aim 1 studied the link between urbanization and the food environment, Aim 2 studied the impact of urbanization on Chinese children's Western FF consumption, while Aim 3 studied urbanization's impact on children's weight status.

Figure 3.1 Conceptual Framework of the Impact of Urbanization on Children's Western Fast Food Consumption and Weight



PA: Physical Activity; PAE: Physical Activity Environment; LUTE: Land Use/Transportation Environment; KAB: Knowledge, Attitudes and Behavior.

Figure 3.2 Analysis Model for the Impact of Urbanization on Children's Western Fast Food Consumption and Weight



3.2 DATA, STUDY SAMPLE AND KEY VARIABLES

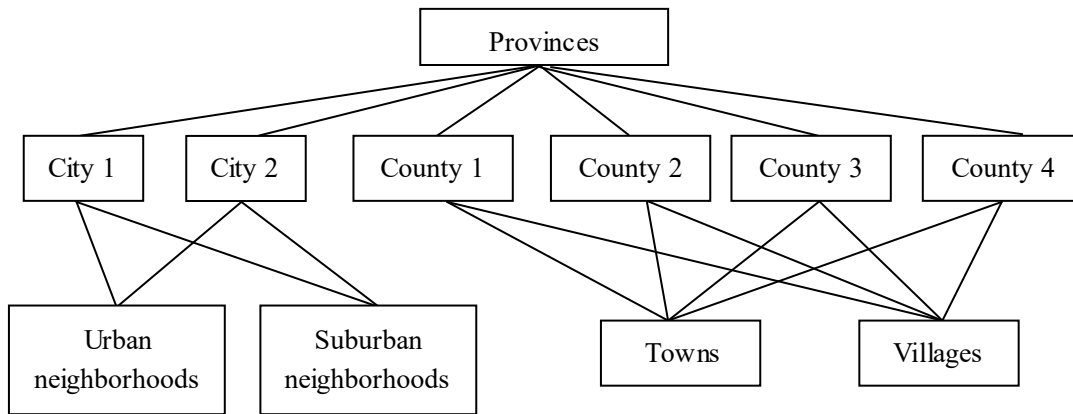
3.2.1 Data: China Health and Nutrition Survey

This study used data collected during 2004- 2011 from the CHNS, which is a large-scale, household-based open cohort survey to examine changes in population health and nutrition in China. It used a multi-stage, random cluster sampling scheme which collected nine waves of data in 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009 and 2011. In collaboration with the University of North Carolina at Chapel Hill, the China Center for Disease Control and Prevention (CDC) conducted surveys in initially eight and later nine provinces of China, including Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guangxi, Guizhou and Heilongjiang (Heilongjiang has been included since 1997). Since the 2011 wave, the three largest municipal cities in China: Beijing, Shanghai, and Chongqing have been added (Popkin, Du, Zhai, & Zhang, 2010a).

Two urban cities and four counties were randomly selected from each of these provinces by a weighted sampling scheme using average income. Afterwards, urban and suburban neighborhoods were randomly selected from cities while townships and villages were randomly selected from counties (**Figure 3.3**) (Popkin, Du, Zhai, & Zhang, 2010b; B. Zhang, Zhai, Du, & Popkin, 2014)

Community was defined as urban neighborhoods, suburban neighborhoods, towns (county capital city), and rural villages, which were the primary sampling units (PSU) in the CHNS. The total population in each community varied from a couple of hundred to several thousand. There were 216 to 273 communities between 2000 and 2011, and 15 to 30 households from each community participated in this study.

Figure 3.3 Sampling Schemes of the China Health and Nutrition Survey



Though the areas under survey are more urbanized than the country as a whole and so are not nationally representative, this survey still covers a large proportion of the total Chinese population (47% in 2011) with substantial regional and socio- demographic coverage (B. Zhang et al., 2014). With the rich amount of information collected in this survey, we can attempt to explore the influence of urbanization on the food environments, especially those pertinent to the growth of Western FF industry, and look into its impact on children’s Westernized diet and weight status.

Most of the research questions used data collected from the most recent four waves of data gathered: 2004, 2006, 2009& 2011, with the exception of Q1b, which used data collected from eight waves: 1989-2009. **Table 3.1** shows a list of key variables used in this study across different waves.

Table 3.1 Variable Availability for Hypotheses across Survey Waves

Variables	Survey Waves								
	1989	1991	1993	1997	2000	2004	2006	2009	2011
Predictor									
Urbanicity score	X	X	X	X	X	X	X	X	X
Aim 1: urbanization vs. food environment									
Q1a: Distribution of food outlets						X	X	X	

Q1b: Food prices	X	X	X	X	X	X	X	X	
Q1c: Community norms						X	X	X	
Diet knowledge						X	X	X	
Food preferences						X	X	X	
Western FF consumption						X	X	X	
Aim 2: urbanization vs. Western FF consumption									
Outcome: Western FF consumption						X	X	X	X
Q2a: mediated by physical environment						X	X	X	X
Q2b: mediated by economic environment						X	X	X	X
Q2c: mediated by socio-cultural environment						X	X	X	X
Aim 3: urbanization vs. weight status									
Outcome: Weight outcomes						X	X	X	X
Q3a: mediated by physical environment						X	X	X	X
Q3b: mediated by economic environment						X	X	X	X
Q3c: mediated by socio-cultural environment						X	X	X	X

3.2.2 Study population

For Aim 1 (Q1a-1c), all communities with the key data needed for the analyses (e.g., urbanicity index, data on food environments) were included, which totals 216 communities. For Aim 2 (Q2a- c), 1,407 children between age six and 18 who had complete information on Western FF consumption (the question on Western FF consumption was only reported for children older than six) were included. For Aim 3 (Q3a-

c), 1,878 children between age two and 18 who had complete information on their BMI were included.

3.2.3 Definitions of Key Study Variables

Fast food and fast food outlets. The term “fast food” was first used in 1951. It is difficult to define FF, as there is no consensus regarding its definition for research purposes (Jeffery et al., 2006). Features that usually characterize FF include its cheap price, being pre-made and quickly served, with a relatively limited menu, of low nutritional value, being offered with no or limited table service, take-away service option with disposable wrappings, being finger food (no need for cutlery), dependence on commercial advertising, and easy brand recognition (Abdollah, 2007; Currie et al., 2009; Jeffery et al., 2006). In addition to the conventional hot food selections such as hamburgers and French fries, there is a debate over whether to include cold snack-type food such as donuts, ice-cream and desserts as FF (Scully, Dixon, & Wakefield, 2009). Because of its ambiguous definition, people have diverse ideas about the term FF. A qualitative study among Swedish high school students found girls tended to define FF based on a chain restaurant context as compared to home-made food, while boys tended to define FF based on its unwholesomeness and satiety (Mattsson & Helmersson, 2007).

Because of the difficulty in defining FF, researchers usually use the types of food served in FF outlets or restaurants as a substitute classification. Nevertheless, problems still exist. The distinction between FF outlets and full-service restaurants is not made clear by the U.S. Census Bureau; and full-service restaurants also serve high-fat, energy-dense food (Burdette & Whitaker, 2004; Chou et al., 2004).

In previous studies, a broad definition of FF outlets was built around certain some features. For example, Block et al (2004) used chain restaurants with two or more of the following features: (1) offering expedited food service; (2) offering take-out service; (3) having limit or no wait staff; or (4) having payment made before food is served (Block, Scribner, & DeSalvo, 2004). Some researchers used a narrow definition with only the largest FF chains (Alter & Eny, 2005; Crawford et al., 2008; Maddock, 2004; Pearce et al., 2009).

Another common way to define FF outlets is using industry classifications such as the North American Industry Classification System (NAICS) Codes (e.g. code #722211) or Standard Industrial Classification (SIC) Codes (e.g. code #5812/40, 58120300-58120303, 58120305-58120315) (Fleischhacker et al., 2011).

In addition, a direct application of the concept of FF and FF restaurants in the Western world to China requires a closer look, as illustrated by the different ways Pizza Hut operates in China (similar to a full-service restaurant) compared with in the U.S.

Built on the previous work and this study's research questions, we used a narrow definition, defining Western FF and Western FF outlets as shown in **Table 3.2**:

Table 3.2 Definition of Fast Food and Fast Food Outlets in China

Terms	Definition	Examples (not exclusive)
Western fast food	<ol style="list-style-type: none"> 1. Typical types of food served in common Western fast food chains 2. Originates in the Western world 	Burgers, fried chicken, French fries, pies, and pizza
Western fast food outlets	<ol style="list-style-type: none"> 1. Standardized operation 2. Franchised chains operated by Western enterprises 3. Limited menu 4. No/little consideration for nutrition 	<u>Burger and chicken places:</u> McDonald's, KFC, Burger King; <u>Pizza places:</u> Pizza Hut, Domino's Pizza

Supermarkets and grocery stores. Supermarkets are defined as having 50 or more employees, while grocery stores are defined as having fewer than 50 employees (Gibson, 2010).

3.2. 4 Study Variables

CHNS provides detailed information on individual-, household- as well as community-level variables.

Table 3.3 provides a list of all variables included in this study.

Table 3.3 List of Study Variables Used in This Study

Construct	Variables	Scale	Notes
Outcome-Key (Child-level)			
Children's weight status	BMI z-score	continuous	Z-scores was defined by the internal age- gender specific cutoff points; overweight and obesity was defined using the IOTF BMI reference for children
	Overweight ($\geq 85^{\text{th}}$ age- gender specific percentile)	yes/no	
	Obesity ($\geq 95^{\text{th}}$ age- gender specific percentile)	yes/no	
Western fast food consumption	Consumed Western fast food or not	yes/no	
	frequency of Western fast food consumption (# of times in the past three months)	Continuous 0, 1-2, 3 or above	frequency of Western fast food consumption (times in the past three months)
Outcome-Intermediate (Community-level)			
Physical food environment	Access to supermarkets (density, availability &	continuous yes/no	# within 30 minutes' bus ride for community residents;

	proximity)		
	Access to free markets (density, availability & proximity)	continuous yes/no	# within 30 minutes' ride for community residents;
	Access to Western fast food outlets (density, availability & proximity)	continuous yes/no	# within 30 minutes' ride for community residents;
	Access to other indoor restaurants (density, availability & proximity)	continuous yes/no	# within 30 minutes' ride for community residents;
Food price	Grains (rice & flour); Cooking oil (soybean oil); Vegetables (most commonly eaten); Fruits (apples); Meat, poultry and	Continuous	1. Unit is yuan per jin/500 grams; 2. Reported by community heads or appropriate vendor/salesperson in the community survey;

	eggs (fatty & lean pork)		<p>3. Used free market prices and added large store retail prices if not available for free market;</p> <p>4. Inflated to 2011 currency</p>
Community norms	Prevalence of Western fast food consumption	continuous	<p>Question: During the past 3 months, how many times have you eaten at a Western fast food restaurant, such as McDonald's or Kentucky Fried Chicken?</p> <p>Compile all the answers from the community;</p>
	Community norms for Western fast food preference	continuous	<p>5-point likert scale</p> <p>Compile all the answers from the community;</p>
	Community norms for diet knowledge	continuous	<p>5-point likert scale</p> <p>Compile all the answers from the community;</p>
Main Predictors (Community-level)			

Urbanicity index		Continuous	Adapted from the urbanicity scale
Control Variables			
Community- level			
Geographical region	Nine provinces	Dummy	Eight dummy variables for regions (provinces)
Household- level			
Mother's education	Mother's education	High (college & graduate degree) Medium (high school or vocational) Low (below high school)	
Household income	Per capita family income	High/Medium/low	Sum of all nine potential sources of income in the family, inflated to the 2011 currency, and divided by household size; all households were trichotomized into three income groups at each study wave.
Child- level			

Age		Continuous (in years)	
Gender		Male/female	
Race/ethnicity		Han/not	

3.2.4.1 Dependent variables

Consists of two different levels of study outcome: key outcomes and intermediate outcomes.

Key Outcomes

1) Weight status

CHNS included anthropometric measures of weight and height. Internal BMI z-scores were calculated and International Obesity Task Force (IOTF) cut- off points were used to define overweight and obesity in children (Cole, Bellizzi, Flegal, & Dietz, 2000). These sex-age-specific BMI cut points were developed using data collected from six countries and correspond to the BMI cut points used in adults, BMI=25 kg/m² for overweight and BMI=30 kg/m² for obesity, respectively. Note that to assist international comparisons, we chose not to use the local Chinese BMI cut points. Another key reason is that the current Chinese BMI reference for overweight and obesity only covered children aged seven and above.

2) Western fast food consumption

Information on Western FF consumption was collected from a single item: “During the past 3 months, how many times have you eaten at a Western FF restaurant, such as McDonald’s or Kentucky Fried Chicken?” This question was only answered by children aged six to 18. It was treated as both a continuous and dichotomous variable.

Intermediate Outcome- Mediators

(1) Access to food outlets- indicators of the physical environment

Since CHNS 1989, the community survey has included information on access to state stores and collaborative. But it was not until 2004 that the study team began to collect similar data about supermarkets and restaurants. Community heads reported the number of food outlets in (e.g. supermarkets within the community) and close to the community (e.g. supermarkets within 30 minutes by bus for community residents). From those reports, we calculated density of food service establishments (including Western FF outlets and other indoor restaurants) and food retail places (including free markets and supermarkets) within each residential community, as an indicator of the local food environment.

(2) Food prices- indicators of the economic environment

In CHNS community surveys, food prices have been collected from a set of stores and markets in each community since CHNS 1989. Data contained both large store retail prices and free market prices. Free market prices were obtained from visits to stores in the community. We used free market prices for our analysis, or large store retail prices if prices for a certain food were not available as free market prices. We looked into prices for major food groups including grains (rice& flour), cooking oil (soybean oil), meat products (pork), vegetables, and fruits (apple). We inflated food prices using the consumer price index (CPI) to account for variations in inflation across years.

(3) Community norms for diet knowledge, food preferences and Western FF consumption- indicators of the socio- cultural environment

Community norms were calculated from individual responses to questions on diet knowledge, FF preferences, and Western FF consumption.

Fast food consumption. Community norms for FF consumption were aggregated from individual

children's responses (ages 6- 18) from each community. This innovative approach was used in a previous study (Rimal et al., 2011).

Nutrition knowledge. There were 12 five-point Likert- scale items ("1 strongly disagree", "2 somewhat disagree", "3 neutral", "4 somewhat agree", "5 strongly agree" and "9 unknown") inquiring about individuals' nutrition knowledge in the adult and child surveys. Sample questions include: "Do you strong agree, somewhat disagree or disagree with this statement- Eating a lot of sugar is good for one's health?" We summed the score for all respondents aged 12 or above in a specific community to gauge their diet knowledge.

Fast food preference. Food preference for FF was measured using 5- point Likert scale questions ("1 dislike very much", "2 dislike somewhat", "3 neutral", "4 like somewhat", "5 like very much" and "9 do not eat this") for both parents and children in the adult and child survey. We summed up the proportion of those aged 12 or above in a specific community who preferred FF to indicate the community norms for FF preference in that community.

Independent variables

This study used the urbanicity scale developed by Jones-Smith and Popkin by removing two items (which were a total of 10 items): the traditional and modern markets, as these two items are associated with the physical environment (which is an intermediate outcome) (Jones-Smith & Popkin, 2010)

Control variables

Socio- demographics

Individual- and household- level socio-demographic profiles including age, gender, ethnicity, and family SES (mother's education levels and per capita family income, inflated by the CPI) were used as control

variables and were adjusted for in our analyses. These variables were extracted from the child and adult survey.

3.3 DATA ANALYSIS

Both cross-sectional and longitudinal analysis, exploratory data analysis and in-depth analysis were conducted for each study aim respectively. Mainly, random-effect models were fit to test the associations between exposure and outcome variables (see **Table 3.4**), while structural equation models (SEM) were fit to test the mediation effect of the food environment. Some further analyses stratified by sex and age were conducted as well. Following provided more details.

3.3.1 Exploratory Data Analysis

Data was checked and cleaned for missing and extreme values. The urbanicity score and household income were previously constructed and ready for use (with minor changes). Reliability and validity of the urbanicity score was tested using the reported dichotomous administrative urban/rural construct to confirm previous studies as reported in paper 1 (Wu et al., 2016). The urbanicity score from 2000 to 2009 was displayed in the descriptive data table along with other individual-, household- and community- level socio-demographic variables. Analyses were completed using Stata 14.0 (College Station, Maryland).

3.3.2 Analysis for Aim1

Density was calculated by dividing the number of different food outlets by area (#/ square km), and also by number of residents in that community (# / capita).

As analysis for Aim 1 was at the community level, to examine if levels of urbanization were associated

with the density, availability and proximity of food environment, we fit two- level (with time nested in communities) mixed- effects logistic regressions and zero- inflated negative binomial regressions with generalized estimating equation (GEE) with a random intercept and an unstructured covariance matrix. The model setting was:

$$\text{logit}(y=1)_{t,i} = \beta_{0,i} + \beta_1 * \text{urban}_{t,i} + \beta_2 * \text{wave}_t + \beta_3 * \text{province}_i + \beta_4 * \text{wave}_t * \text{urban}_{t,i}$$

Where i =community i , t =wave t ;

3.3.3 Analyses for Aims 2 and 3

For Aim 2 and Aim 3, both individual- level analyses, we fit three- level (children at different waves nested in communities) random- effects linear and logistic regression models with a child- specific and a community- specific random intercept to test if urbanization is related to children's Western FF consumption and weight outcomes (as continuous or dichotomous outcomes), without accounting for indicators of food environments:

$$\text{logit}(WS=1)_{ijt} = \beta_0 + \beta_1 * \text{urban}_{jt} + \beta_2 * \text{com}_j + \beta_3 * \text{hh}_{ijt} + \beta_4 * \text{ind}_{ijt} + \beta_5 * \text{wave}_t + b_{0i} + b_{1i} + \varepsilon$$

Where i =child i , j =community j , t =wave t (wave 2004 when $t=0$, 2006 when $t=1$, 2009 when $t=2$, 2011 when $t=3$); WS = weight status, $urban$ =urbanicity index, com =other community- level variables (geographical regions), hh =household- level variables, ind =individual- level variables, $wave$ =dummy variables for study waves, b_{0i} =child- specific intercept, b_{1i} =community- specific intercept, ε =error terms.

Later, we added indicators for food environments to the regression models and fit structural equation model (SEM) to examine mediation effects of the three dimensions of the food environment on the pathway from urbanization to children's Western FF consumption and weight outcomes. First, we put the potential mediators (indicators of food environment) in our generalized SEM one at a time (e.g., only the density of FF outlets as mediator), fitting similar multi- level models as above. Then we kept those statistically

significant indicators in our final SEM to check how the impact of urbanization of children's Western FF consumption, weight status and BMI z-scores were mediated by the food environment. Arrows were removed if regression coefficients were insignificant.

Table 3.4 Settings of Regression Analyses in Three Papers

	Outcome	Predictor	Covariate	Model
Paper 1	Density, availability and proximity of four types of food establishments	urbanicity	Study wave, province, study wave*urbanicity	Two- level logistic & zero- inflated negative binomial regression
	Food prices			GEE
	Community norms for FF consumption, preference and nutrition knowledge			GEE
Paper 2	FF consumption		Age, ethnicity, household income, maternal education, study wave, geographic regions	Three- level random – effect linear model
	Consumed FF or not			Three- level random – effect logistic model
Paper 3	BMI z- score			Three- level random – effect linear model
	Overweight/obese or not			Three- level random – effect logistic model

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CHAPTER 4: THE IMPACT OF URBANIZATION ON COMMUNITY FOOD ENVIRONMENTS IN CHINA

Abstract

Background and objectives: Research on how urbanization has influenced the food environments in China is limited. The study aims to examine the impact of urbanization on the food environments in China.

Methods and study design: Longitudinal data collected during 1989-2009 from the China Health and Nutrition Survey (CHNS) were used, which covered 9 provinces in China. Urbanicity index (0-10) was assessed using a scale for 10 components (population density, economic activities, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, social services). Final analyses included 216 communities. Random-effect models were used in analyses.

Results: Urbanization (higher urbanicity index) increased the odds of having fast food restaurants (OR=2.78, 95% CI: 2.18-3.54) and other indoor restaurants (OR=2.93, 95% CI: 2.28-3.76) within the community, the odds of having supermarkets (OR=2.43, 95% CI: 2.04-2.89) and free markets (OR=2.56, 95% CI: 1.77-3.70) within 30 minutes' bus ride from the community. Food prices for apples (β =0.06, 95% CI: 0.04-0.08) and lean pork (β =0.02, 95% CI: 0.01-0.03) increased with urbanicity, while prices for other food did not. Urbanicity was positively associated with community norms for fast food consumption (RR=1.28, 95% CI: 1.22-1.33), fast food preferences (RR=1.09, 95% CI: 1.06-1.12) and nutrition knowledge (RR=1.02, 95% CI: 1.01-1.03).

Conclusions: Urbanization is associated with food environments in China. The findings provide insight for future economic development and public health effort related to urbanization.

Keywords: urbanization; food environments; fast food; policy; China

INTRODUCTION

Urbanization has been taking place in many developing countries although it is at a faster rate in some countries compared to others, which likely has many impacts on people's behaviors and health. China has been undergoing urbanization at an accelerating pace in the past three decades. The level of urbanization, as illustrated by the proportion of urban dwellers, rose from less than 20% in 1978 to almost 50% in 2009 (Zhu et al., 2011). This has brought dramatic changes to both the environment and to individuals' lifestyles as well as health outcomes in China. For example, physical activity (PA) levels of Chinese adults declined by a third between 1991 and 2006, especially occupational PA due to changes in the work structure (Monda et al., 2007; S. W. Ng et al., 2009). About half of the decline could be explained by urbanization factors, including dynamics in the housing infrastructure, sanitation and availability of higher education institutions (S. W. Ng et al., 2009).

Changes in the environment and lifestyles induced by urbanization entail new health challenges for the country, in particular the rising epidemic of obesity and chronic diseases (Popkin, 1999; Youfa Wang, Mi, Shan, Wang, & Ge, 2006). China is undergoing a rapid nutrition transition with dual burdens of both under-nutrition and over-nutrition (Popkin, 1999, 2008; W. Yang et al., 2010). Prevalence of obesity and other non-communicable

diseases (NCDs) have been increasing (Youfa Wang et al., 2006). National data show that at present approximately one third of Chinese adults and 10 to 20% of children are either overweight or obese; and about 20% of adults have hypertension or dyslipidemia (Youfa Wang et al., 2006; Youfa Wang, Monteiro, & Popkin, 2002); and the prevalence of diabetes among men and women aged 20 and above from 14 provinces and municipalities in China reached nearly 10% in 2007-2008 (W. Yang et al., 2010). The prevalence of overweight and obesity among Chinese school children increased from less than 2% in 1985 to 15% in 2010 (JI & CHEN, 2013). The situation in the most urbanized, metropolitan areas was even worse, with rates of childhood obesity comparable to those in developed countries. A nationally representative survey of school- age children in China reported that in 2010, almost one third of boys and one fifth of girls were either overweight or obese in the most urbanized, large coastal cities, while the rate was over 30% among both male and female youths in the United States, as shown by reports from the National Health and Nutrition Examination Survey (NHANES) in 2011-2012 (JI & CHEN, 2013; C Y Ji & Cheng, 2009; Cheng Ye Ji & Cheng, 2008). The prevalence of diabetes among Chinese adults living in urban areas was found to be doubled than that of rural areas (S M Attard et al., 2012).

It is crucial to examine the impact of urbanization on food environments, which shapes people's diet and health profile (Fraser, Edwards, Cade, & Clarke, 2010; Moore, Diez Roux, Nettleton, & Jacobs, 2008; Pearce, Hiscock, Blakely, & Witten, 2009; Lisa M. Powell, Auld, Chaloupka, O'Malley, & Johnston, 2007; Lisa M Powell, Han, & Chaloupka, 2010).

However, there have been limited studies focusing on the impact of urbanization on food environments in China (Fraser et al., 2010; X. Zhang, van der Lans, & Dagevos, 2012); and

few studies have assessed what aspects of urbanization are more deleterious.

The classification and measurement of the obesogenic environment remains to be a controversial issue. The ANGELO (ANalysis Grid for Elements Linked to Obesity) framework proposed by Swinburn, partitioned the obesogenic environments into four different parts: the physical environment, economic environment, socio-cultural environment and political environment (Swinburn, Egger, & Raza, 1999). Such an approach makes it easier to measure and define the obesogenic environment, and will be used in the current study.

This study investigated the impact of urbanization on food environments in China using nationwide longitudinal survey data, and further explored such association by different aspects of urbanization. We focused on three different dimensions of the food environments from the ANGELO framework: (1) local food environment as a feature of the physical environment; (2) community-level food prices as a key feature of the economic environment; and (3) community norms of nutrition knowledge, FF preferences, and FF consumption levels as key features of the community-level socio-cultural environment.

MATERIALS & METHODS

Study Design, Data and Sample

This study used a nationwide, longitudinal dataset from the China Health and Nutrition Survey (CHNS), which started in the year 1989 until most recently. For the physical and socio-cultural environment, we used data collected in 2004, 2006 and 2009 as questions related to most of those two components were not included until 2004. Meanwhile, we

included food prices with all waves, as information on those were gathered in waves dating back to 1989. CHNS was an ongoing, household-based, open-cohort survey using a multi-stage, random cluster sampling scheme. It covered nine provinces across China, including Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guangxi, Guizhou and Heilongjiang, thus representing a wide range of geographic and socio-demographic regions in China. The community survey was largely reported by community heads or salespersons (Popkin et al., 2010a; B. Zhang et al., 2014).

The geographical unit of analysis was urban or suburban neighborhoods and/or rural villages. The average size of neighborhood and/or village in this study ranged from 10.21 to 19.20 square kilometers, and the range of population size was 4,384 to 5,538 per geographical unit.

Our study protocol was approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB) and the University at Buffalo IRB.

Outcome variables: Measures of Food Environments

This study used three different dimensions of obesogenic food environments as defined in the ANGELO framework, including the physical, economic, and socio-cultural environment (Swinburn et al., 1999).

1) The physical environment was the local food environment, taking into account four different types of food retail and service establishments: FF restaurants (mostly Western franchises, e.g. McDonalds, KFC), other indoor restaurants, supermarkets, and free markets (open-air markets). It also incorporated three types of indicators: availability, density and

proximity. Availability was defined as whether there were any food establishments in the neighborhood (for FF or other indoor restaurants), or within 5 kilometers (approximately 30 minutes' bus ride) from the neighborhood (for supermarkets and free markets). Density was defined as the number of food establishments per square kilometer, or per 1,000 residents. Proximity was defined as distance to the nearest food establishment in kilometers. This information was obtained from community leaders with questions like: *"How many supermarkets or hypermarkets are within 5 kilometers of this village/neighborhood?"*

2) The economic environment was operationalized as community- level food prices. They were collected from vendors or salespersons. Free market prices were used. If free market prices were not available, large store prices were used. Food items included those commonly consumed by Chinese adults and children, including prices for grains (rice, unbleached flour), oils (rapeseed oil, soybean oil, peanut oil, cottonseed oil), vegetables, fruits (apples, oranges), meat/poultry/egg products (lean pork, chicken, beef, mutton, fish, egg), dairy products (fresh milk) and soft drinks (Coca-Cola, Jianlibao).

3) The socio-cultural environment was measured by community norms of nutrition knowledge, Western FF preferences and consumption based on available data collected from children. They were aggregated from individual children's responses from each community. A sample question was: *"During the past 3 months, how many times have you eaten at a Western FF restaurant, such as McDonald's or Kentucky Fried Chicken?"* Indicators used included the mean score of nutrition knowledge for all participating children in the community, prevalence of children preferring FF, and prevalence of children who had consumed FF over the prior three months. We chose to include only community norms

among children rather than adults for the powerful peer influence on children's dietary behaviors.

Independent Variables: Urbanicity Index

In this study, we used a continuous urbanicity index rather than an urban-rural dichotomy. We modified a previously published urbanicity scale developed based on the CHNS data, which exhibited great measurement quality.²³ The previous urbanicity scale included twelve elements, while we removed two elements: the traditional and modern markets, considering they were highly correlated to our main study outcomes - the food environments.

Our modified urbanicity scale included ten elements, each with a score range from 0 to 10: population density, economic activity, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services (see **Appendix 4.A** for more details). Data for each element were retrieved from the CHNS community survey and thus reported by community heads or salesperson. The final urbanicity index (range 0- 10) was obtained by taking an average of the sum score of the ten elements.

Appendix 4.A: The Ten Dimensions of the Urbanicity Scale†

The description of the dimensions was from the cited reference:

1. Population density (0-10): total population of the community divided by community size, from official records;
2. Economic activity (0-10): typical daily wage for an ordinary male worker (reported by

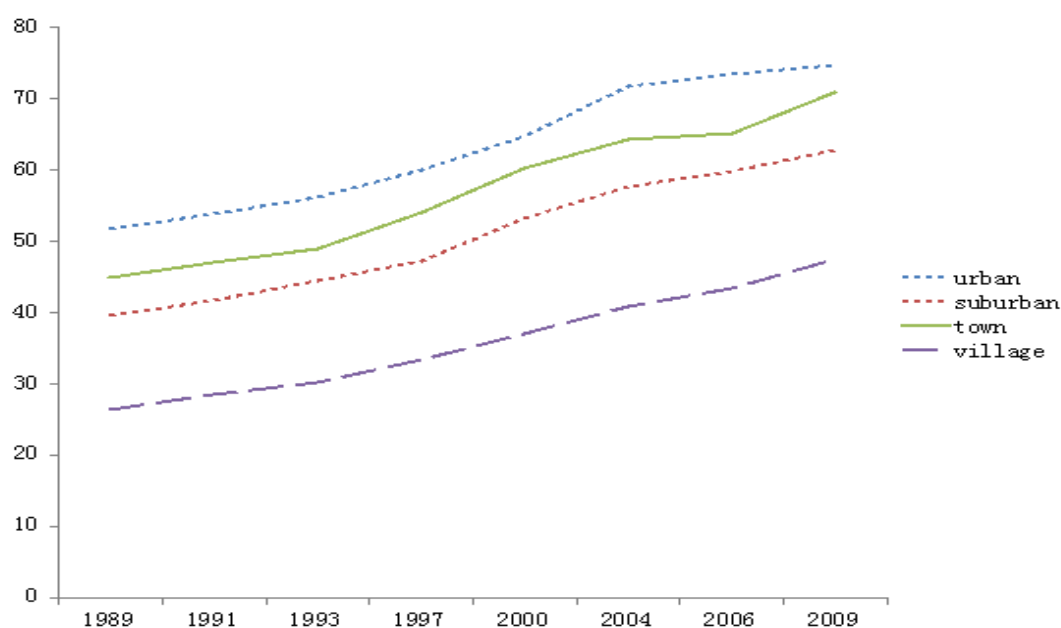
- community officials), and % of the population engaged in nonagricultural work;
3. Transportation infrastructure (0-10): most common types of road, mean distance to bus stop, and to train stop;
 4. Sanitation (0-10): proportion of households with treated water, and prevalence of households without excreta present outside the home;
 5. Communications (0-10): availability of a cinema, newspaper, postal service, telephone service, and % of households with a computer, % of households with a television, and % of households with a cell phone;
 6. Housing (0-10): average number of days a week that electricity is available to the community, % of community with indoor tap water, % of community with flush toilets, and % of community that cooks with gas;
 7. Education (0-10): average education level among adults >21 years old;
 8. Diversity (0-10): variation in community education level, and variation in community income level;
 9. Health infrastructure (0-10): number and type of health facilities in or nearby (≤ 12 km) the community, and number of pharmacies in the community;
 10. Social services (0-10): provision of preschool for children under 3, availability of commercial medical insurance, free medical insurance, and/or insurance for women and children.

†Reference: Jones-Smith, J. C., & Popkin, B. M. (2010). Understanding community context and adult health changes in China: development of an urbanicity scale. *Soc Sci Med*,

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Our factor analysis showed that the modified urbanicity scale was uni-dimensional, and had a high test-retest reliability across waves (correlation coefficient $r=0.84$ to 0.92). Its test-retest reliability was higher in consecutive waves than in non-consecutive waves. Results from item-scale correlations analyses showed moderate to high item-scale correlation ($r=0.47$ to 0.89). The generated urbanicity index can distinguish the four official designations well, with urban neighborhoods obtaining the highest scores, followed by towns, suburbs and villages, indicating good criterion-related validity (**Figure 4.1**). Furthermore, kappa coefficients indicated low to moderate agreement ($\kappa=0.04$ to 0.26) while Spearman correlation coefficients indicated high agreement ($r=0.68$ to 0.74).

Figure 4.1. Over-time Change in Urbanicity Index across Waves by Official Designation (residence) in Nine Provinces in China during 1989-2009 †‡



† Based on data collected from the China Health and Nutrition Survey during 1989-2009. The urbanicity scale includes 10 components: population density, economic activities, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services. The potential sum score can range from 0 to 10. Higher scores indicate greater levels of urbanicity.

‡ Official designation includes urban, suburban, town and villages. This definition was obtained from those at baseline (1989).

Covariates

Study wave (year), study wave*urbanicity interactions and province were included as dummy variables in our models.

Statistical Analysis

Analyses were conducted using STATA 14 (StataCorp, 2015). Descriptive statistics in wave 2004, 2006 and 2009 were displayed and were compared across waves.

Multi-level logistic regressions, with a random intercept and an unstructured covariance matrix were used to examine the effect of urbanization on the availability of four types of food retail and service establishments: FF restaurants, other indoor restaurants, supermarkets and free markets in wave 2004, 2006 and 2009. The general model was shown as below:

$$\text{logit}(y=1)_{t,i} = \beta_{0,i} + \beta_1 * \text{urban}_{t,i} + \beta_2 * \text{wave}_t + \beta_3 * \text{province}_i + \beta_4 * \text{wave}_t * \text{urban}_{t,i}$$

Where i=community i, t=wave t;

Three different models were fit. The first model used only the urbanicity index as a predictor, while the second model also controlled for study wave and province. The third model used the ten elements of the urbanicity index as predictors. Variance inflation factor indicated no problem with multi- collinearity.

Due to over-dispersion and a large number of zero observations, we used zero-inflated negative binomial regressions with generalized estimating equation (GEE) to examine the effect of urbanization on food density, proximity, as well as the average nutrition knowledge, the prevalence of FF consumption and FF preferences. The first model showed the crude association, while the second model controlled for study wave and province.

For community norms of nutrition knowledge, GEE with robust variance estimation were used, adjusting for study wave and province using data from wave 2004, 2006 and 2009.

For community- level food prices, random- effects models were used with jackknife estimation for standard errors, adjusted for study wave and province, using data from wave 1989 to 2009.

RESULTS

General Community Characteristics and Changes in Food Environments

The number of communities investigated in 2004, 2006 and 2009 was 216, 217 and 217, respectively. Community follow-up was more than 90%. Community ranged from 10.21 to 19.20 square kilometers, containing 4,364 to 5,338 residents, and 1,249 to 1,407 households (Table 4.1).

The average urbanicity index (range: 0-10) increased from 5.26 (SD: 1.58) in 2004 to 5.85 (SD: 1.52) in 2009. Tests to examine the trend in food environments found a significant decline in density of other indoor restaurants, supermarkets, and free markets, better proximity to free markets, and greater availability of FF restaurants (from 16.9% in 2004 to 24.4% in 2009). Prices increased for all food items except jianlibao, a local soft drink brand. Prevalence of FF consumption and FF preferences increased significantly, from 19.1% to 27.1%, and 44.8% to 47.7% during 2004 and 2009 ($p < 0.05$); while scores in nutrition knowledge did not change much.

Table 4.1. Characteristics of Sampled Communities and Changes in the Food Environments from 2004 to 2009 in China: CHNS 2004-2009 †

	Survey wave		
	2004 (n=216) mean (SD)	2006 (n=217) mean (SD)	2009 (n=217) mean (SD)
Community characteristics			
population in community	5002(6089)	4364(7249)	5338(9098)
area size of community (km ²)	16.05 (77.56)	19.20 (73.78)	10.21 (53.37)
household number in community	1249(2592)	1286(1401)	1407 (1456)
urbanicity index (0-10)	5.27 (1.58)	5.48 (1.56)	5.85 (1.52)
Neighborhood by community type			
urban neighborhood, n (%)	35 (16.2)	36 (16.6)	35 (16.1)
suburban neighborhood, n (%)	37 (17.1)	37 (17.1)	37 (17.1)
town neighborhood, n (%)	36 (16.7)	36 (16.6)	37 (17.1)
rural village, n (%)	108 (50.0)	108 (49.8)	108 (49.8)
Physical food environment			
<i>Density (# per 1,000 residents)</i>			
fast food restaurants	0.14 (0.65)	0.10 (0.45)	0.04 (0.15)
other indoor restaurants	3.82 (7.77)	3.35 (5.70)	2.88 (5.21)*
supermarkets	2.23 (5.20)	1.14 (3.66)*	0.85 (1.86)*
free markets	2.45 (5.25)	1.27 (1.89)*	1.03 (1.42)*
<i>Density (# per square kilometer)</i>			
fast food restaurants	0.85 (5.33)	0.14 (0.49)*	0.35 (2.01)
other indoor restaurants	34.00 (167.14)	6.36 (12.29)*	12.80 (38.27)*
supermarkets	10.26 (42.50)	2.09 (6.75)*	3.42 (8.57)*
free markets	10.03 (47.69)	2.74 (13.66)*	4.55 (18.72)
<i>Proximity (Distance to the nearest such store in km)</i>			
supermarket	6.26 (11.09)	4.95 (8.32)	4.47 (8.42)
free market	14.99 (29.22)	1.75 (3.52)*	1.25 (2.32)*
<i>Availability (% available)</i>			
fast food restaurant	36 (16.8)	37 (17.1)	52 (24.4)*
other indoor restaurant	149 (69.6)	161 (74.5)	152 (70.4)
supermarket	143 (67.5)	107 (49.8)*	127 (60.2)
free market	198 (94.3)	200 (93.5)	199 (92.6)
Economic food environment‡			
price for most commonly eaten rice (per jin)	1.27 (0.85)	1.34 (0.22)	1.65 (0.59)*
price for unbleached flour (per jin)	1.42 (1.65)	1.30 (0.66)	1.57 (0.38)

price for rapeseed oil (per jin)	4.08 (1.62)	3.57 (0.87)*	5.47 (1.83)*
price for soybean oil (per jin)	3.86 (1.33)	3.86 (2.32)	4.96 (1.80)*
price for peanut oil (per jin)	5.51 (2.28)	5.62 (1.59)	7.24 (1.83)*
price for cottonseed oil (per jin)	3.63 (1.54)	3.47 (1.11)	4.77 (2.78)*
price for eggs (per jin)	3.16 (1.17)	3.32 (1.02)	4.25 (1.47)*
price for most commonly eaten vegetable (per jin)	0.76 (0.91)	0.94 (0.93)*	1.32 (0.83)*
price for apples (per jin)	1.38 (0.72)	1.85 (0.70)*	2.51 (0.92)*
price for oranges (per jin)	1.14 (0.59)	1.32 (0.45)*	1.52 (0.88)*
price for lean pork (per jin)	8.54 (1.32)	7.46 (1.40)*	11.5 (1.87)*
price for cleaned chicken (per jin)	6.02 (2.11)	6.16 (2.84)	7.60 (2.62)*
price for beef (per jin)	8.52 (2.10)	9.19 (2.35)*	17.46 (3.66)*
price for mutton (per jin)	9.12 (2.74)	9.96 (3.06)*	17.92 (4.68)*
price for fresh milk (per parckage-250mL)	1.55 (0.95)	1.99 (1.90)*	2.16 (0.92)*
price for mostly commonly eaten fish (per jin)	4.32 (2.32)	4.14 (1.25)	5.77 (2.88)*
price for coca-cola (per can-335mL)	2.52 (1.04)	2.84 (2.04)*	3.24 (2.76)*
price for jianlibao (per can-335mL)	2.47 (0.77)	2.87 (2.25)*	1.57 (0.38)*

Socio-cultural food environment§

prevalence of fast food consumption (%)	19.06 (25.50)	20.35 (27.49)	27.14 (31.66)*
prevalence of fast food preferences (%)	44.78 (35.58)	34.97 (31.78)*	47.69 (37.90)*
average score for nutrition knowledge (0-12)	8.72 (1.75)	8.37 (1.65)	8.51 (1.80)

† Based on data collected from the China Health and Nutrition Survey (CHNS) conducted in 2004, 2006 and 2009. CHNS covered 9 provinces in China;

* p<0.05, indicating significant difference from wave 2004; p-value obtained from zero-inflated negative binomial regressions for density, proximity, fast food prevalence and preference, from random-effect logistic models with random intercept for availability; from GEE poisson for price and nutrition knowledge;

‡ Free market prices were used. If free market prices were not available, large state store prices were used; prices were inflated to 2009 using consumer price index (CPI);

§ Socio-cultural food environment was measured by aggregating individual responses from children living in each community, to show community norms for nutrition knowledge, fast food preferences, and fast food consumption.

Validation of Urbanicity Scale with Official Designations

Index scores obtained from the modified urbanicity scale showed great agreements with

the official designation of urban, suburban neighborhoods, towns and villages in 1989 (Figure 4.1). Urban neighborhoods scored the highest in urbanicity index, followed by towns and suburban neighborhoods, while rural villages scored the lowest in urbanicity index. Meanwhile, all four types of neighborhoods/villages showed a parallel increasing temporal trend in the urbanicity scale.

Association between Urbanization and the Physical Food Environment

Availability. Table 4.2 shows that after adjusting for study wave, study wave*urbanicity interactions and province, a one unit increase in the urbanicity index accounted for increased odds of the availability of FF restaurants (OR=3.23, 95% CI: 2.08-5.00), other indoor restaurants in the community (OR=3.04, 95% CI: 2.15-4.30), as well as increased odds of supermarkets (OR=2.34, 95% CI: 1.77-3.08) and open-air free markets (OR=2.88, 95% CI: 1.39-5.97) within 30 minutes' bus ride from the community. Results were similar for models with no adjustments for covariates (results not shown here).

Further analyses indicated a significant positive effect of population density (OR=1.37, 95% CI: 1.10-1.70), sanitation (OR=1.34, 95% CI: 1.08-1.66), health infrastructure (OR=1.31, 95% CI: 1.12-1.52) and economic activity (OR=1.23, 95% CI: 1.07-1.43) on FF restaurant availability; a significant positive effect of communication (OR=1.29, 95% CI: 1.01-1.64), health (OR=1.18, 95% CI: 1.05-1.33) and social services (OR=1.24, 95% CI: 1.08-1.43) on other indoor restaurant availability; a significant positive effect of communication (OR=1.26, 95% CI: 1.02-1.55), health infrastructure (OR=1.21, 95% CI: 1.09-1.34), economic activity (OR=1.11, 95% CI: 1.01-1.22) and education/income diversity (OR=1.34, 95% CI: 1.02-1.77)

on supermarket availability; and a significant positive effect of communication (OR=1.53, 95% CI: 1.07-2.18) on free market availability.

Density. **Table 4.3** reveals a positive effect of urbanization on the density (# per square kilometers) of all four categories of food establishments (adjusted OR=3.69, 3.04, 2.38 and 2.05 for FF restaurants, other indoor restaurants, supermarkets and free markets, respectively). For each one unit increase in the urbanicity score, the expected number of FF restaurants per square kilometer within a community increased by 2.7 times, after controlling for study wave, study wave*urbanicity interactions and province. The patterns were less obvious when using number per 1,000 residents as indicators of density.

Proximity. **Table 4.3** illustrates a significant shorter distance to supermarkets (RR=0.59, 95% CI: 0.50-0.70) and free markets (RR=0.54, 95% CI: 0.47-0.62) with increased urbanicity.

Table 4.2. Multi-level logistic regression to examine the impact of urbanization on the availability of food establishments in China: CHNS 2004-2009 (N=221 communities) †‡§¶††

	Fast food restaurant			Other indoor restaurant			Supermarket			Free market		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
<i>Model 1: urbanicity index+wave+urbanicity*wave interaction+province</i>												
Urbanicity	3.23	2.08, 5.00	***	3.04	2.15, 4.30	***	2.34	1.77, 3.08	***	2.88	1.39, 5.97	**
<i>Model 2: all urbancity components+wave+urbanicity*wave interaction+province</i>												
population density	1.37	1.10, 1.72	**	1.10	0.88, 1.37		0.97	0.82, 1.16		1.25	0.86, 1.81	
education	1.03	0.78, 1.36		0.89	0.64, 1.25		0.85	0.65, 1.11		1.18	0.63, 2.21	
sanitation	1.34	1.08, 1.66	**	1.06	0.90, 1.24		1.03	0.91, 1.17		0.97	0.76, 1.23	
housing	0.94	0.72, 1.22		1.25	0.99, 1.58		1.18	0.98, 1.43		1.1	0.77, 1.59	
transportation	0.92	0.79, 1.05		1.07	0.94, 1.20		1.00	0.90, 1.10		1.13	0.93, 1.37	
communication	1.17	0.88, 1.54		1.29	1.01, 1.64	*	1.26	1.02, 1.55	*	1.53	1.07, 2.18	*
health	1.31	1.12, 1.52	***	1.18	1.05, 1.33	**	1.21	1.09, 1.34	***	0.92	0.77, 1.10	
economy	1.23	1.07, 1.43	**	1.05	0.94, 1.17		1.11	1.01, 1.22	*	1.14	0.96, 1.37	
diversity	0.98	0.73, 1.32		1.08	0.78, 1.51		1.34	1.02, 1.77	*	1.35	0.76, 2.42	
social service	1.01	0.91, 1.12		1.24	1.08, 1.43	**	1.02	0.93, 1.163		0.95	0.74, 1.21	

* p<0.05, ** p<0.01 *** p<0.001

† Based on data from the China Health and Nutrition Survey (CHNS) in 2004, 2006 and 2009;

‡ Based on mixed-effects logistic regression models (xtmelogit) with random intercept and unstructured covariance matrix to examine cross-sectional association between urbanicity index and food environments across waves;

§ Model 1: urbanicity is the predictor, availability of food establishments is the outcome, adjusting for study wave, study wave*urbanicity interaction and province;

Model 2: Ten components (population density, economic activities, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, social services) of the urbanicity index are the predictors, availability of food establishments is the outcomes, adjusting for study wave, study wave*urbanicity interaction and province;

†† For fast food restaurant and other indoor restaurant, availability was defined as having or not having inside the neighborhood; For supermarket and free market, availability was defined as having or not having within 30 minutes' bus ride.

Table 4.3. Zero-inflated negative binomial regression to examine the impact of urbanization on the community-level physical and socio-cultural food environments in China: CHNS 2004-2009 (N=221 communities) †‡§¶

		Urbanicity		
		RR	95% CI	p
Physical food environment				
<i>Density (# per 1,000 residents)</i>				
	fast food restaurant	0.96	0.54,1.70	
	other indoor restaurant	1.32	1.17,1.48	***
	supermarket	1.02	0.87,1.20	
	free market	1.02	0.92,1.14	
<i>Density (# per square kilometer)</i>				
	fast food restaurant	3.69	2.59,5.27	***
	other indoor restaurant	3.04	2.39,3.86	***
	supermarket	2.38	1.88,3.01	***
	free market	2.05	1.69,2.49	***
<i>Proximity (Distance to the nearest... in kilometers)</i>				
	supermarket	0.59	0.50,0.70	***
	free market	0.54	0.47,0.62	***
Socio-cultural food environment††				
	prevalence of fast food consumption (%)	1.28	1.22,1.33	***
	prevalence of fast food preferences (%)	1.09	1.06,1.12	***
	average score for nutrition knowledge ⁶	1.02	1.01,1.03	***

* p<.05 ** p<.01 *** p<.001

† Based on data from the China Health and Nutrition Survey (CHNS) in 2004, 2006 and 2009;

‡ Based on data from zero-inflated negative binomial regression (ZINB) with clustering at the community level; SE were obtained from robust variance estimation; variables used in the first step were obtained from xtmeologit in Table 2;

§ Urbanicity as the predictor, adjusting for study wave, province and urbanicity*study wave interaction;

¶ Questions on fast food consumption were responded by children above age six; questions on fast food preferences and nutrition knowledge were responded by children above age 12;

†† For nutrition knowledge, GEE poisson regression was used with robust variance estimation.

Association between Urbanization and the Socio-cultural Food Environment

Table 4.3 reveals a positive association between urbanicity and community norms for FF consumption (RR=1.28, 95% CI: 1.22-1.33), FF preferences (RR=1.09, 95% CI: 1.06-1.12) and nutrition knowledge (RR=1.02, 95% CI: 1.01-1.03) in children.

Association between Urbanization and the Economic Food Environment (Food Prices)

Table 4.4 shows that price for most commonly eaten rice ($\exp(\beta) = 1.01$, 95% CI: 1.01-1.02), unbleached flour ($\exp(\beta) = 1.02$, 95% CI: 1.01-1.03), most commonly eaten vegetable ($\exp(\beta) = 1.08$, 95% CI: 1.04-1.11), apples ($\exp(\beta) = 1.06$, 95% CI: 1.05-1.08) and lean pork ($\exp(\beta) = 1.02$, 95% CI: 1.01-1.03) increased significantly with urbanicity, while prices for other food items did not. Interactions between study wave and urbanization were not found ($p > .05$).

Table 4.4. Random-effect models to examine the impact of urbanization on community economic food environment-- food prices: CHNS 1989-2009 (N=218 communities) †‡§

Type of food categories	Urbanicity		p
	exp(β)	exp (95% CI)	
commonly consumed rice	1.01	1.01, 1.02	**
unbleached flour	1.02	1.01, 1.03	**
cooking oil: rapeseed oil	0.99	0.97, 1.02	
cooking oil: soybean oil	1.00	0.98, 1.02	
cooking oil: peanut oil	1.01	0.99, 1.03	
eggs	1.00	0.98, 1.02	
commonly consumed vegetables	1.08	1.04, 1.11	***
apples	1.06	1.05, 1.08	***
oranges	1.02	0.99, 1.04	
pork	1.02	1.01, 1.03	***
chicken	1.01	1.00, 1.03	
beef	1.00	0.99, 1.02	
mutton	1.01	1.00, 1.03	
fresh milk	0.99	0.97, 1.01	
mostly commonly eaten fish	1.02	1.00, 1.04	
coca-cola (the U.S. brand soft drink)	0.99	0.98, 1.01	
jianlibao (a Chinese brand soft drink)	0.99	0.98, 1.01	

* p<.05 ** p<.01 *** p<.001

† Results from the China Health and Nutrition Survey (CHNS) in 1989, 1991, 1993, 2004, 2006 and 2009;

‡ Free market prices were used. If free market prices were not available, large state store prices were used; prices were inflated to 2009 using consumer price index (CPI);

¶ Random-effects models with robust SE and maximum likelihood estimation, adjusting for study wave and province; separate model was fit for each food price.

DISCUSSION

This study found that urbanization was associated with changes in all the four dimensions of the community food environments (FF restaurants, other indoor restaurants, supermarkets, and open-air free markets). With increased urbanization, food retail and service establishments became more available, existed in greater density, and were more accessible (within a shorter walking distance) for residents. Food prices did not change significantly, except in the case of slightly increased prices for rice, unbleached flour, vegetables, apples and lean pork in more urbanized communities. With increased urbanization, children became more knowledgeable about nutrition; but they preferred and consumed more FF.

We originally hypothesized that more urbanized areas had better access to modern food related market outlets such as supermarkets and restaurants, but had poorer access to traditional markets such as open- air free markets based on some related findings in the U.S (Fleischhacker, Evenson, Rodriguez, & Ammerman, 2011; Ford & Dzewaltowski, 2008; L. M. M. Powell, Slater, Mirtcheva, Bao, & Chaloupka, 2007). However, we found that more urbanized areas had better access to all kinds of food outlets. Traditional and modern markets both have thrived in China over the past 2-3 decades with the increasing urbanization. Supermarkets were initially introduced to China in the 1980s. Since the 2000s, this modern way of retailing has grown rapidly (Mai & Zhao, 2004; Reardon, Timmer, & Minten, 2012). The Chinese are selective in choosing what kind of items to purchase from supermarkets. A study in Shanghai found that most people preferred to buy processed food in supermarkets, while buying fresh food items (mainly vegetables) from traditional free markets (Goldman, 2000). Since the 1990s, the Chinese population has become more accustomed to eat away

from home, while Western FF restaurants and other restaurants are both good alternatives (Popkin et al., 2012; Zhai et al., 2014).

Some components of urbanicity, such as population density, sanitation, communication, diversity, health, economy and social services were found to be significantly associated with greater availability of food places. This corresponds with the fact that FF restaurants were more available in places with a denser population, better sanitation, health facilities and economic conditions, factors influencing where to locate FF chains.

The finding that food prices (adjusted for inflation) did not change much with urbanicity may be due to the Chinese government's effort to regulate (stabilize) food prices. The government monitors food prices on a regular basis and provides recommended prices (S. W. Ng, Zhai, & Popkin, 2008). Thus, food prices surveyed remained relatively stable and did not vary much with urbanicity. Despite this fact, food prices are still an important risk factor to take into account when studying obesity in China (Beydoun, Powell, & Wang, 2008; S. W. Ng et al., 2008).

The cluster of residents living in more urbanized areas were better educated about nutrition, were more favorable to FF and ate in FF restaurants more frequently. There appears to be a mismatch between knowledge, attitudes and actual behaviors. Unlike in the developed countries, many Western FF chains market their products as well balanced, sanitary and healthy. People also have more trust in FF restaurants due to food safety concerns in other food vendors (Beydoun et al., 2008; S. W. Ng et al., 2008). A cross- country study investigated 795 young consumers from China and U.S. and found that the Chinese participants were more favorable towards KFC and were more likely to eat there than their

American counterparts (Witkowski, Ma, & Zheng, 2003). Moreover, people, especially young people living in megacities, cared more about “fast” rather than “food” due to the fast modern life pace (Anderson & He, 1999; Veeck & Burns, 2005). Finally, FF was more accessible and acceptable in more urbanized areas, and this partially leads to the higher prevalence of childhood obesity in urban versus rural areas.

Westernization, as shown by changing lifestyles, may serve to be a confounder between food environments and urbanization; however, while human behaviors such as Westernization shape and change the environment, the environment also changes human behaviors, as suggested by Bandura’s Social Cognitive Theory (McAlister, Perry, & Parcel, 2008).

This study has several key strengths. First, its longitudinal design made it possible to examine whether the association between urbanization and food environments differs by study wave. Second, this is the first study to look into the impact of urbanization (and its different dimensions) on different dimensions of food environments. Third, this study in China, the largest developing country with a fast growing economy, provides useful insights for other developing countries facing the emerging threat of obesity and NCDs.

The study also suffers from a few limitations. First, data on local food environments were reported by community heads, making their accuracy be of concern. Second, there was no information reported on prices of prepared foods (e.g., FF, prepared food sold at other food vendors) except a few reported in the 2009 wave, while nutrients in raw foods are quite different after they are processed. Next, the sample mainly came from the more affluent, eastern provinces, and thus may not well represent the poorer, western provinces.

In conclusion, urbanicity was positively associated with access to all kinds of food

outlets, better nutrition knowledge, and more prevalent FF preferences and consumption. Its association with food prices was not obvious for many, but showed a positive relationship for some foods like the prices for rice, unbleached flour, vegetables, apples and lean pork.

The rapid urbanization in China has brought in both opportunities and threats to public health. The key is to encourage the beneficial components of urbanization, while reduce adverse components. More studies are needed to understand and test such components and interventions, and the mechanisms through which they impact population health. Though food prices did not show a clear link with urbanization, the Chinese government still needs to be cautious about the potential effect of economic growth and price change on food purchasing and consumption, as evidenced in the rising consumption of edible oil and fat. The mismatch between norms on nutrition knowledge and FF consumption urges relevant stakeholders such as policy makers, public health professionals and researchers to promote healthful urbanization and eating.

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CHAPTER 5: THE IMPACT OF URBANIZATION ON CHINESE CHILDREN'S WESTERN FAST FOOD CONSUMPTION: THE MEDIATING ROLE OF THE COMMUNITY FOOD ENVIRONMENT

Abstract

Background and objectives: Research on how urbanization has influenced Chinese children's Western fast food consumption is limited. This study examined the impact of urbanization on Chinese children's Western fast food consumption, and the mediating role of the food environment.

Methods: Longitudinal data from the China Health and Nutrition Survey 2004- 2011 in nine provinces across China were used. Urbanicity index (0-10) was assessed from an urbanicity scale. Final analyses of data on 1,407 children aged 6-18 used random- effect, multi- level models, and generalized structural equation models.

Results: Living in more urbanized communities (versus less urbanized ones) increased the odds of having consumed Western FF consumption in the past three months among both boys (OR=1.98, 95% CI: 1.68~2.35) and girls (OR=1.88, 95% CI: 1.60~2.22). No consistent patterns suggested which components of the food environment mediated the association, but the socio-cultural environment and food prices appear to play a role.

Conclusions: Urbanization is positively associated with Chinese children's Western fast food consumption, and this association is mediated by the food environment. Thus, both urbanization and the food environment need to be considered when designing interventions to reduce children's Western fast food consumption and increasing childhood obesity rates in China.

Keywords: urbanization; food environment; fast food; China; children

INTRODUCTION

Urbanization in China has grown at an ever-accelerating pace since 1978, when the “reform and opening policy” was first introduced and implemented. Urbanization is defined as “the process by which towns and cities are formed and become larger as more and more people begin living and working in central areas” (Merriam-Webster, 2013). By 2014, more than half of the population in China was living in urban areas, compared to only a quarter in 1990. Those figures show that in over just two decades, the fraction of the population living in urban areas more than doubled, while the fraction of people living in rural areas dropped by over a third (Samantha M. Attard et al., 2015; National Bureau of Statistics of China, 2014)

One of the consequences of rapid urbanization in China was to transform the typical diet (J. Zhang et al., 2015). The Chinese diet was traditionally almost entirely plant-based, and has now transitioned into a much more Westernized, animal-based diet (Gordon-Larsen, Wang, & Popkin, 2014; S. W. Ng et al., 2008; Popkin et al., 2012; Su, Jia, Wang, Wang, & Zhang, 2015; Zhai et al., 2014). As a result, the average percent of energy from fat increased by half (from 21.8% in 1991 to 32.0% in 2011), and this increase was more prominent in mega-cities. As a corollary to this increase in calories from fat, the average national consumption of coarse grains decreased from 87.6 kcal/day in 1991 to 25.4 kcal/day in 2011, and was even lower in urban areas. Cooking methods also shifted in ways which increased calorie load: from boiling, baking and steaming to stir-frying. Snacking and meals eaten away from home also became more popular, especially in urban areas (Zhai et al., 2014).

Urbanization in China has led to better access to a variety of foods, and thus increased food diversity (Tian, Wang, Liu, & Fan, 2015). Among the various foods, Western fast food (FF), a symbol of a Westernized diet, has become increasingly popular in China. McDonald’s® opened its first outlet in China in 1990 and soon grew to over 2,000 outlets in just two decades. There are over 4,000 KFC® and Pizza Hut’s® all over the country (Pan, Malik, & Hu, 2012). China now accounts for the substantial majority of KFC®’s

world-wide sales and profit (McDonald's, n.d.). The distribution of Western FF outlets in China also follows an urban to rural gradient in a cross-sectional fashion, with more urbanized cities having more Western FF outlets than found in less urbanized areas (Liao et al., 2016). The popularity in Western FF may in part account for the increased rates of childhood obesity and non-communicable chronic diseases in China. A recent empiric study of 21,198 children aged 2 to 18 in Beijing showed a positive correlation between Western FF consumption and childhood obesity (Shan et al., 2010).

Though some prior studies tried to find a link between urbanization, the spread of Western FF restaurants, and Chinese children's Western FF consumption, few have looked at these three factors simultaneously. Furthermore, few explored the role that the broader definition of "food environment" may play, taking into account three dimensions of the food environment: the physical environment, the economic environment, and the socio-cultural environment, as illustrated by the ANalysis Grid for Elements Linked to Obesity (ANGELO framework) (Swinburn et al., 1999).

To fill these gaps, this study aimed to answer three research questions: 1) whether and how urbanization has impacted Chinese children's Western FF consumption; 2) whether the community-level food environment mediated this relationship; and 3) whether Western FF consumption differed by geographic region after controlling for urbanization effects. The community-level food environment was conceptualized as consisting of three components: (a) the local food environment (the physical environment); (b) community-level food prices (the economic environment); (c) community norms for nutrition knowledge and FF preferences (the socio-cultural environment).

MATERIALS & METHODS

Study Design and Sample

To examine the effects of urbanization on Chinese children's Western FF consumption and test for

possible mediating effects of the food environment, we utilized longitudinal data from children aged 6-18, who were surveyed in the China Health and Nutrition Survey (CHNS) at least twice in 2004, 2006, 2009 and 2011. This sub- sample was chosen because questions on FF preference were added to this survey in 2004 and children within that age range responded. A total of 1,407 children from 213 communities made up our final analytical sample used in these analyses.

The CHNS is a household- based cohort survey. It started in 1989 and followed the same households every two to four years. It is a nationwide study, initially covering nine provinces across China: Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guangxi, Guizhou, and Heilongjiang provinces. Three mega-cities, including Beijing, Shanghai and Chongqing were added in 2011, and three more provinces (Yunan, Shanxi, and Zhejiang) in 2015. However, data from the new mega-cities and provinces were not included in this study because they did not satisfy the criterion of having at least two follow- up surveys available to date.

The CHNS surveyed individuals and households, as well as community representatives. Research staff from the Chinese Centers for Disease Control and Prevention (CCDC) visited randomly- selected households to conduct in- person interviews with individuals and families. Community leaders, and vendors completed the community survey. Population size in each community ranges from 125 to 87,960 people. (Popkin et al., 2010a).

Outcome: Western Fast Food Consumption

Children aged 6- 18 responded to the question: *“During the past 3 months, how many times have you eaten at a Western FF restaurant, such as McDonald’s or Kentucky Fried Chicken?”* in waves 2004, 2006, 2009 and 2011. We evaluated separately for those who reported having eaten or not having eaten at a Western FF restaurant in the three months before each survey time, forming a dichotomous outcome. In

addition, a continuous outcome as the number of times consuming Western FF in the past three months was also used in our analyses.

Exposure: Urbanicity Index

This study used an adapted scale to measure the urbanicity level and this urbanicity scale was based on CHNS (Jones-Smith & Popkin, 2010). Our study removed two components (the traditional and modern markets) from the original twelve- item scale, and assessed their overlaps with our primary mediator- the food environment.

The final urbanicity scale included ten components: population density, economic activity, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services. Each component was rated on a scale from 0- 10, with 0 indicating very low urbanization levels and 10 indicating highly urbanized. Our previous study demonstrated its good measurement quality (Wu et al., 2016). The urbanicity index was obtained by averaging the scores of the ten components (range: 0 to 10).

Mediator: Food Environment

This study hypothesized the community- level obesogenic food environment mediated the relationship between urbanicity and children's consumption of Western FF. Here we examined three dimensions of the food environment: physical environment, economic environment, and socio- cultural environment.

Physical Food Environment

The physical environment was defined as a place where food (whether it was raw or processed) was usually sold, and incorporated four different types of food retail and service establishments:

- (a) FF restaurants: mostly Western franchises, e.g., McDonald's®, KFC®;
- (b) Other indoor restaurants;
- (c) Supermarkets;
- (d) Free markets, i.e. open- air markets.

Nearly every type of food establishments had three kinds of indicators:

- (a) Availability: whether there were any food establishments in the neighborhood for FF restaurants or other indoor restaurants, or within 30 minutes' bus ride from the neighborhood for supermarkets and free markets (dichotomous: available/ not available);
- (b) Density: the number of food establishments per 1,000 residents (continuous);
- (c) Proximity: distance to the nearest food establishment in kilometers (km), only available for supermarkets and free markets (continuous).

Only data on density were used in later analyses because it had higher data quality and was easier to interpret than other indicators.

Economic Food Environment

The economic environment was measured by the prices of common foods available in the community. The CCDC research team surveyed vendors or salespersons inside each community to collect free market food prices for some typical food items. Our study included prices for grains (rice, unbleached flour), oils (soybean oil), vegetables (the most commonly consumed vegetables), fruits (apples), meat/poultry/egg products (fatty& lean pork), as they were typical foods consumed daily by Chinese families and were potentially relevant to FF consumption.

Consumer price index (CPI) for urban and rural residents living within each province or mega- city was

retrieved from the National Bureau of Statistics of China (National Bureau of Statistics of China, 2014). However, CPIs reported by the National Bureau of Statistics of China were constructed using the previous year as base. Thus, I adjusted CPI using the 2004 year value as base. For example:

$$A_CPI_{j,2006}=CPI_{j,2005}*CPI_{j,2006}$$

A_CPI_{2006} : Adjusted CPI in community j in the year 2006;

$CPI_{j,2005}$: CPI in community j in the year 2005;

$CPI_{j,2006}$: CPI in community j in the year 2006.

Prices in waves other than 2004 were deflated to the 2004 year values for better comparisons, based on each community's adjusted CPI. For example, for Community "j":

$$I_Price_{j,2006}=Price_{j,2006}\div A_CPI_{j,2006}$$

$I_Price_{j,2006}$: food prices in community j in the year 2006 deflated to the 2004 values;

$Price_{j,2006}$: actual food prices in community j in the year 2006;

$A_CPI_{j,2006}$: Adjusted CPI in community j in the year 2006.

We imputed food prices in two steps: First, if free market prices were not available, large- store prices were used. Second, we replaced missing values with province- average for that food item at the same wave.

Socio-cultural Food Environment

The community- level socio- cultural environment was measured by community norms for nutrition knowledge and FF preference. They were aggregated from individual's responses from each community. A

sample question for FF preference was: “Please use 1-5 to describe how much you like FF (KFC®, pizza, hamburgers, etc.): dislike very much, dislike, neutral, like, or like very much.” The mean score of nutrition knowledge and proportion of individuals preferring FF in the community were used as indicators for descriptive norms.

Covariates

Child gender was considered as a potential effect modifier. Thus, analyses were stratified by gender.

Other potential confounders in the relationship between urbanicity index and children’s FF consumption came from different levels:

- (a) Community- level: geographic regions;
- (b) Household- level: family socio- economic status (SES), as reflected in per capita household income (in Chinese Yuan) and mother’s education levels;
- (c) Individual- level: child age, ethnicity (Han or not). Han is the major ethnic group in China;
- (d) Other: study wave, i.e., the four waves: 2004, 2006, 2009 and 2011.

Statistical Analysis

All analyses were conducted using STATA 14.0 (StataCorp, 2015). Baseline characteristics (when each child participated for the first time) were compared between those who consumed FF over the past three months, versus those who did not.

To examine our first and third research questions regarding the association between urbanization and geographic regions on children’s Western FF consumption, we fit three- level mixed models with a random intercept for each child, since individuals from different waves were nested within communities. Analyses were stratified by gender and adjusted for the community-, household- and individual- level covariates

mentioned above. The general model is shown as below:

$$\text{logit}(\text{FF}=1)_{ijt} = \beta_0 + \beta_1 * \text{urban}_{jt} + \beta_2 * \text{region} + \beta_3 * \text{cov} + b_{0i} + b_{1i} + \varepsilon$$

where i =child i , j =community j , t =wave t ($t=0, 1, 2, 3$ when year is 2004, 2006, 2009, and 2011);

FF= consumed FF or not, urban=urbanicity index, region=geographic regions, cov=covariates, b_{0i} = child-specific random intercept, b_{1i} = community- specific random intercept, ε =error terms.

Similarly, we conducted multi- level modeling when the outcome was the frequency of FF consumption (continuous) following:

$$\text{FFC}_{ijt} = \beta_0 + \beta_1 * \text{urban}_{jt} + \beta_2 * \text{region} + \beta_3 * \text{cov} + b_{0i} + b_{1i} + \varepsilon$$

where i =child i , j =community j , t =wave t ($t=0, 1, 2, 3$ when year is 2004, 2006, 2009, and 2011);

FFC= frequency of FF consumption, urban=urbanicity index, region=geographic regions, cov=covariates, b_{0i} = child- specific random intercept, b_{1i} = community- specific random intercept, ε =error terms.

Finally, we conducted structural equation modeling (SEM) to test our second hypothesis, i.e., food environment mediated the relationship between urbanization and children's Western FF consumption (when analyzed as both continuous and dichotomous outcomes). First, each indicator for food environment was separately tested for its mediation effect across all study waves with SEM, fitting multi- level random- effect models controlled for potential confounders. Next, only indicators with statistically significant mediation effects were put in the final SEM, and the arrows for insignificant effects were taken out, forming the final path diagrams.

RESULTS

Baseline Characteristics

A total of 1,517 children were included in this study if they appeared at least twice in the dataset between 2004 and 2011, after 2,061 children were excluded due to loss to follow-up. Compared to children who participated at least twice in CHNS, those participating only once tended to be older, thinner, more likely to be of Han ethnicity, and had higher maternal education level. They were also more likely to be living in more urbanized communities, with better access to FF, other indoor restaurants and free markets, with higher food prices, and from communities with stronger norms for FF preferences and greater levels of nutrition knowledge (all $p < .001$, except $p < .05$ for access to other indoor restaurants and free markets).

(Appendix 5.A)

Appendix 5.A: Comparisons of Baseline Characteristics between Chinese Children Who Remained in the Study and Those Lost-to-followups: CHNS 2004-2009 (N=4073)^{1,2,3}

	Lost-to-followup (n=2061) Mean (SD)	Remained(n=1517) Mean (SD)	Sig
CHILD AND HOUSEHOLD CHARACTERISTICS			
overweight/obese, n (%) ⁴	137 (7.3)	148 (10.9)	***
age	11.79 (3.79)	9.39 (2.74)	***
girl, n (%) ⁴	970 (47.0)	718 (47.3)	
Han ethnicity, n (%) ⁴	1821 (88.4)	1272 (84.0)	***
Mother's education, n (%) ⁴			
<High school	1197 (69.8)	1059 (81.2)	
High school/vocational	336 (19.6)	212 (16.3)	
College& master	183 (10.7)	34 (2.6)	***
Household income, n (%) ^{4,5}			
Low	667 (33.0)	535 (35.7)	
Medium	713 (35.2)	523 (34.9)	
High	646 (31.9)	441 (29.4)	
COMMUNITY CHARACTERISTICS			
Urbancity index (0-10)	5.72 (1.73)	5.08 (1.50)	***
Urban, n (%) ⁴	725 (35.1)	420 (27.7)	***
	Median (IQR)	Median (IQR)	
1)Physical environment			
<i>Density (# per 1,000 residents)</i>			
fast food restaurant	0 (0)	0 (0)	***
other indoor restaurant	1 (2.82)	0.97 (3.45)	
supermarket	0.34 (1.06)	0.43 (1.37)	
free market	1.10 (1.79)	1.05 (1.63)	
<i>Proximity (Distance to the nearest... in kilometers)</i>			
supermarket	1.8 (4.5)	2 (5.5)	
free market	0.95 (5)	1 (10)	*
<i>Availability (n, % available)⁴</i>			
fast food restaurant	546 (26.5)	218 (14.5)	***
other indoor restaurant	1430 (69.6)	998 (66.4)	*
supermarket	1179 (58.3)	835 (56.2)	
free market	874 (91.8)	1057 (92.4)	
	Mean (SD)	Mean (SD)	
2)Economic environment (Unit price in Chinese Yuan/500 grams)			
⁵			
price for most commonly eaten rice	1.99 (0.43)	1.41 (0.28)	***
price for unbleached flour	1.92 (0.69)	1.46 (0.63)	***
price for soybean oil	6.49 (2.61)	4.64 (1.63)	***
price for most commonly eaten vegetable	1.34 (0.70)	0.89 (0.69)	***
price for apples	4.61 (3.07)	1.86 (0.98)	***
price for fatty& lean pork	11.99 (3.46)	7.74 (1.57)	***

3) Socio-cultural environment

prevalence of fast food preferences (%)	6.48 (6.24)	4.84 (4.61)	***
average score for nutrition knowledge (0-12)	8.36 (0.97)	8.24 (1.03)	***

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ for comparisons between different weight status groups; obtained from ANOVA tests for normal data, Wilcoxon-Mann Whitney test for non-normal data, and chi-squared test for categorical data.

1 Results from the China Health and Nutrition Survey (CHNS) in 2004, 2006 and 2009, when children aged 6-18 appeared for the first time.

2 BMI was calculated from measured weight and height, and categorized using the IOTF cutoffs for children.

3 Obtained from question: "During the past 3 months, how many times have you eaten at a Western fast food restaurant, such as McDonald's or Kentucky Fried Chicken?".

4 % stands for column %. For example, among non-Western fast food consumers, 10.7% ($n=136$) had access to fast food restaurants.

5 Household income was defined as income per capita, inflated to the 2011 year values and trichotomized into low/medium/high groups for each wave.

6 Urbanicity index (0-10) was obtained by averaging scores on ten components: population density, economic activity, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services.

7 Free market prices were used. If free market prices were not available, large state store prices were used; prices were inflated to 2011 using consumer price index (CPI).

8 Average scores on nutrition knowledge questions, aggregated from all respondents within each community.

Compared to children who denied consuming Western FF during the past three months, those who reported having consumed Western FF were more likely to be living in more urbanized communities (consumers vs. non-consumers: 58.0% versus 21.9%, $p < .001$), with higher density of FF restaurants ($p < .001$), other indoor restaurants ($p < .001$) and supermarkets ($p < .001$), and lived closer to both supermarkets (1 vs. 2 km, $p < .001$) and free markets (0 vs. 1.5 km, $p < .001$), and had greater availability of all four food establishments: FF restaurants (33.7% vs. 10.7%, $p < .001$), other indoor restaurants (83.1% vs. 63.1%, $p < .001$), supermarkets (82.0% vs. 51.2%, $p < .001$), and free markets (96.6% vs. 91.6%, $p < .05$).

Children who reported consuming FF in the past three months were significantly more likely to be living in communities with more expensive vegetables (1.01 vs. 0.86 yuan (Chinese currency)/500 grams (g), $p < .01$), apples (1.98 vs. 1.83 yuan/500 g, $p < .05$), and fatty& lean pork (7.94 vs. 7.71 yuan/500 g, $p < .05$), and cheaper soybean oil (4.45 vs. 4.68 yuan/500 g, $p < .05$). Dwellers in those communities were also more likely to prefer FF and be more knowledgeable about nutrition ($p < .001$).

For child-level characteristics, those reporting having consumed FF over the past three months tended to be older (9.80 vs. 9.31 years old, $p<.01$), of Han ethnicity (93.1% vs. 82.2% Han, $p<.001$), and of higher socio- economic status (SES) families, compared to non- consumers ($p<.001$). (**Table 5.1**)

Table 5.1: Baseline Community-, Household- and Child-level Characteristics by Children's Western Fast Food Consumption: CHNS 2004-2009^{1,2}

	Consumed Western fast food in the past 3 months ³			
	All (n=1517)	No (n=1272)	Yes (n=245)	
	Mean (SD)	Mean (SD)	Mean (SD)	Sig
CHILD AND HOUSEHOLD CHARATERISTICS				
Age	9.39 (2.74)	9.31 (2.72)	9.80 (2.80)	**
girl, n (%) ⁴	718 (47.3)	592 (46.5)	126 (51.4)	
Han ethnicity, n (%) ⁴	1273 (83.9)	1045 (82.2)	228 (93.1)	***
Mother's education, n (%) ⁴				
<High school	1163 (82.7)	1027 (87.3)	136 (59.1)	
High school/vocational	208 (14.8)	130 (11.1)	78 (33.9)	
College& master	36 (2.6)	20 (1.7)	16 (7.0)	***
Household income, n (%) ^{4,5}				
Low	535 (35.7)	478 (38.0)	57 (23.7)	
Medium	523 (34.9)	464 (36.9)	59 (24.5)	
High	441 (29.4)	316 (25.1)	125 (51.9)	***
COMMUNITY CHARACTERISTICS				
Urbancity index (0-10) ⁶	5.08 (1.50)	4.81 (1.39)	6.49 (1.25)	***
Urban, n (%) ⁴	420 (27.7)	278 (21.9)	142 (58.0)	***
	Median (IQR)	Median (IQR)	Median (IQR)	
FOOD ENVIRONMENTS				
1)Physical environment				
Density (# per 1,000 residents)				
fast food restaurant	0 (0)	0 (0)	0 (0)	***
other indoor restaurant	0.97 (3.45)	0.85 (2.96)	2 (4.59)	***
Supermarket	0.43 (1.37)	0.12 (1.28)	0.90 (1.61)	***
free market	1.05 (1.63)	1.03 (1.71)	1.08 (1.54)	
Proximity (Distance to the nearest such outlet in kilometers)				
Supermarket	2 (5.5)	2 (7)	1 (2.2)	***
free market	1 (10)	1.5 (10)	0 (5)	***
Availability (n, % available) ⁴				
fast food restaurant	218 (14.4)	136 (10.7)	82 (33.7)	***
other indoor restaurant	998 (66.4)	796 (63.1)	202 (83.1)	***
supermarket	835 (56.2)	639 (51.2)	196 (82.0)	***
free market	1057 (92.4)	887 (91.6)	170 (96.6)	*
	Mean (SD)	Mean (SD)	Mean (SD)	
2)Economic environment (Unit price in Chinese Yuan/500 grams) ⁷				
price for most commonly eaten rice	1.41 (0.28)	1.41 (0.28)	1.44 (0.26)	
price for unbleached flour	1.46 (0.63)	1.44 (0.60)	1.52 (0.76)	
price for soybean oil	4.64 (1.63)	4.68 (1.63)	4.45 (1.66)	*
price for most commonly eaten vegetable	0.89 (0.69)	0.86 (0.67)	1.01 (0.76)	**
price for apples	1.86 (0.98)	1.83 (0.99)	1.98 (0.93)	*
price for fatty& lean pork	7.74 (1.57)	7.71 (1.53)	7.94 (1.77)	*

3) Socio-cultural environment

prevalence of fast food preferences (%)	4.84 (4.61)	4.52 (4.48)	6.52 (4.90)	***
average score for nutrition knowledge (0-12) ⁸	8.24 (1.03)	8.11 (1.02)	8.93 (0.78)	***

* p<0.05 ** p<0.01 *** p<0.001 for comparisons between those consumed Western fast food vs. those did not; obtained from two-sample t-tests for normal data, Wilcoxon-Mann Whitney test for non-normal data, and chi-squared tests for categorical data.

1 Results from the China Health and Nutrition Survey (CHNS), of children who were followed at least twice. Baseline is when children were observed for the first time (wave 2004 - 2009).

2 Mean and SD used for normal data; median and inter-quartile range (IQR) used for non-normal data; n and % used for categorical data.

3 Obtained from question: "During the past 3 months, how many times have you eaten at a Western fast food restaurant, such as McDonald's or Kentucky Fried Chicken?".

4 % stands for column %. For example, among non-Western fast food consumers, 10.7% (n=136) had access to fast food restaurants.

5 Household income was defined as income per capita, inflated to the 2011 year values and trichotomized into low/medium/high groups for each wave.

6 Urbanicity index (0-10) was obtained by averaging scores on ten components: population density, economic activity, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services.

7 Free market prices were used. If free market prices were not available, large state store prices were used; prices were inflated to 2011 using consumer price index (CPI).

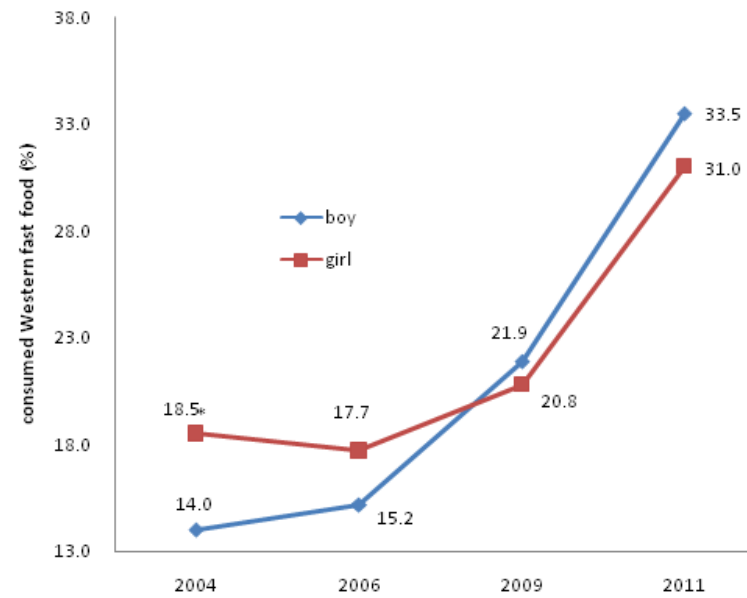
8 Average scores on nutrition knowledge questions, aggregated from all respondents within each community.

Trends in Western Fast Food Consumption

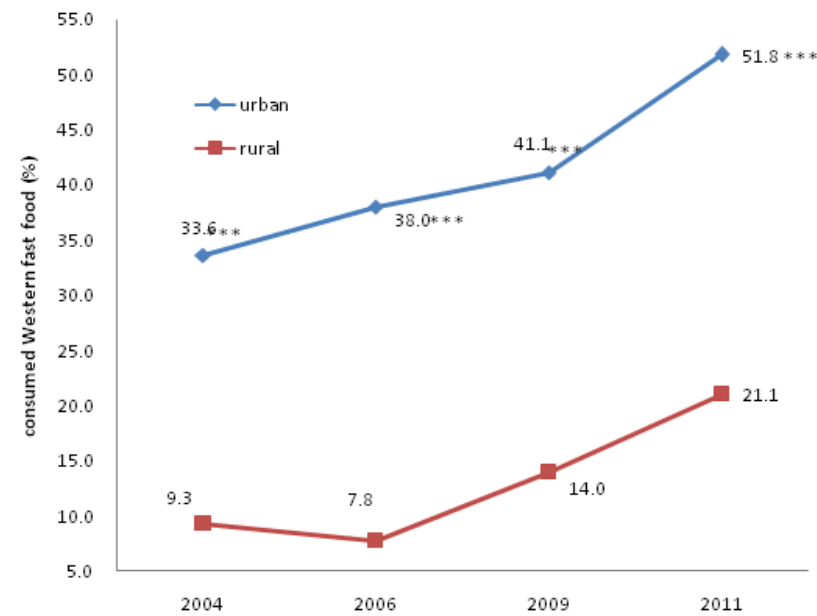
The proportion of children reporting having consumed Western FF in the past three months more than doubled, from 2004 (16.1%) to 2011 (32.3%). More girls consumed Western FF than boys (18.5% vs. 14.0%, p<0.05) in 2004, but this difference has been outpaced by boys since 2009 (20.8% vs. 21.9%). More children living in urban areas reported consuming Western FF than their rural counterparts, at all time points surveyed. There was no obvious difference between children (aged 6- 12) and adolescents (aged 13- 17) in the rates of Western FF consumption in 2004, though adolescents showed a statistically significantly higher consumption rate in 2009 (26.2% vs. 18.6%) (**Figure 5.1**).

**Figure 5.1. Time Trends in Chinese children's Western Fast Food Consumption by Gender,
Urbanicity and Age Groups, CHNS 2004-2011(n=5,849)^{1,2}**

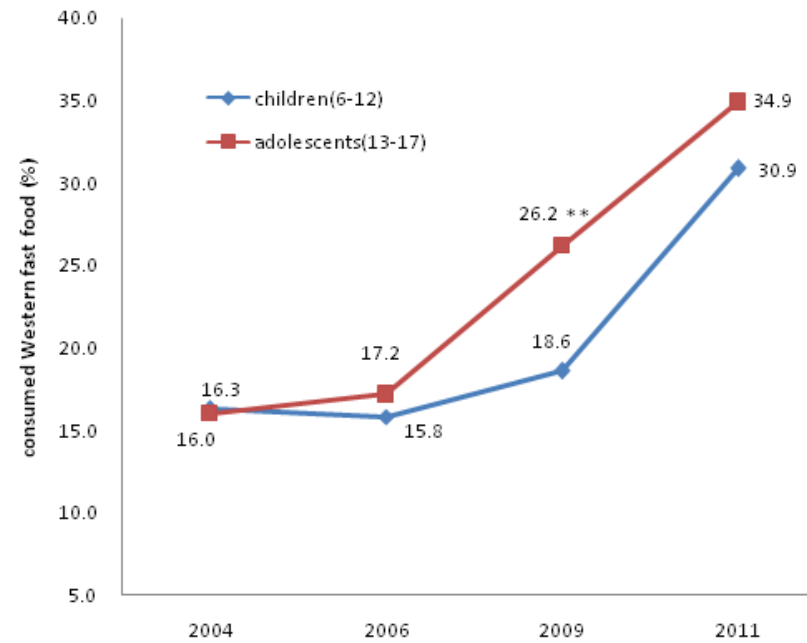
(a). By gender



(b). By Urbanicity



(c). By Age Groups



* $p < .05$ ** $p < .01$ *** $p < .001$ for chi-squared tests that Western fast food consumption differs by the grouping variable at that wave.

¹ Based on data from children aged 6-18, who participated in the China Health and Nutrition Survey (CHNS) in 2004, 2006, 2009 and 2011.

² Fast food consumption: having eaten at a Western fast food restaurant or not in the past 3 months.

Association between Urbanization, Geographic regions and Western Fast Food Consumption

Living in more urbanized communities was significantly related to more Western FF consumption in both boys (OR=1.98, 95% CI: 1.68~2.35) and girls (OR=1.88, 95% CI: 1.60~2.22).

Western FF consumption differed by geographic region, even after controlling for urbanicity and other covariates. Compared to children living in Northeast China, both boys and girls from South China were 75% less likely to report consuming Western FF during the past three months (boys OR=0.25, 95% CI: 0.12~0.55; girls OR=0.25, 95% CI: 0.12~0.54).

Similar findings were seen when Western FF consumption was treated as a continuous outcome (see **Table 5.2**)

Table 5.2: Multi-level Regressions to Examine the Impact of Urbanization on Chinese Children's Western Fast Food Consumption: CHNS 2004-2011^{1,2,3}

		Boys (n=749)			Girls (n=658)		
		OR	95% CI	sig	OR	95% CI	sig
<i>Model 1: outcome as having eaten at a Western fast food restaurant or not (dichotomous)²</i>							
Urbanicity		1.98	1.68, 2.35	***	1.88	1.60, 2.22	***
Geographic region ⁴							
	Central China vs. Northeast	0.59	0.32, 1.08		0.68	0.38, 1.23	
	West China vs. Northeast	1.26	0.65, 2.42		0.83	0.43, 1.59	
	South China vs. Northeast	0.25	0.12, 0.55	***	0.25	0.12, 0.54	***
	Southwest vs. Northeast	0.20	0.08, 0.48	***	0.57	0.26, 1.22	
<i>Model 2: outcome as # of times having eaten at a Western fast food restaurant (continuous)³</i>							
Urbanicity		0.24	0.15, 0.33	***	0.20	0.10, 0.30	***
Geographic region ⁴							
	Central China vs. Northeast	0.01	-0.28, 0.31		-0.11	-0.47, 0.26	
	West China vs. Northeast	0.17	-0.23, 0.57		-0.14	-0.49, 0.22	
	South China vs. Northeast	-0.31	-0.61, -0.02	*	-0.49	-0.76, -0.22	***
	Southwest vs. Northeast	-0.21	-0.53, 0.10		-0.12	-0.46, 0.22	

* p<0.05, ** p<0.01 *** p<0.001

1 Based on data from children aged 6-18, who participated at least twice in the China Health and Nutrition Survey (CHNS) in 2004, 2006, 2009 and 2011.

2 Based on mixed-effect linear regression models (xtmixed) with a random intercept for children, controlling for study wave, geographic regions, age, ethnicity, household income and mother's education.

3 Based on mixed-effect logistic regression models (xtmelogit) with a random intercept for children, controlling for study wave, geographic regions, age, ethnicity, household income and mother's education.

4 Northeast: Liaoning, Heilongjiang; Central China: Henan, Hunan, Hubei; East China: Jiangsu, Shandong; South China: Guangxi; Southwest: Guizhou.

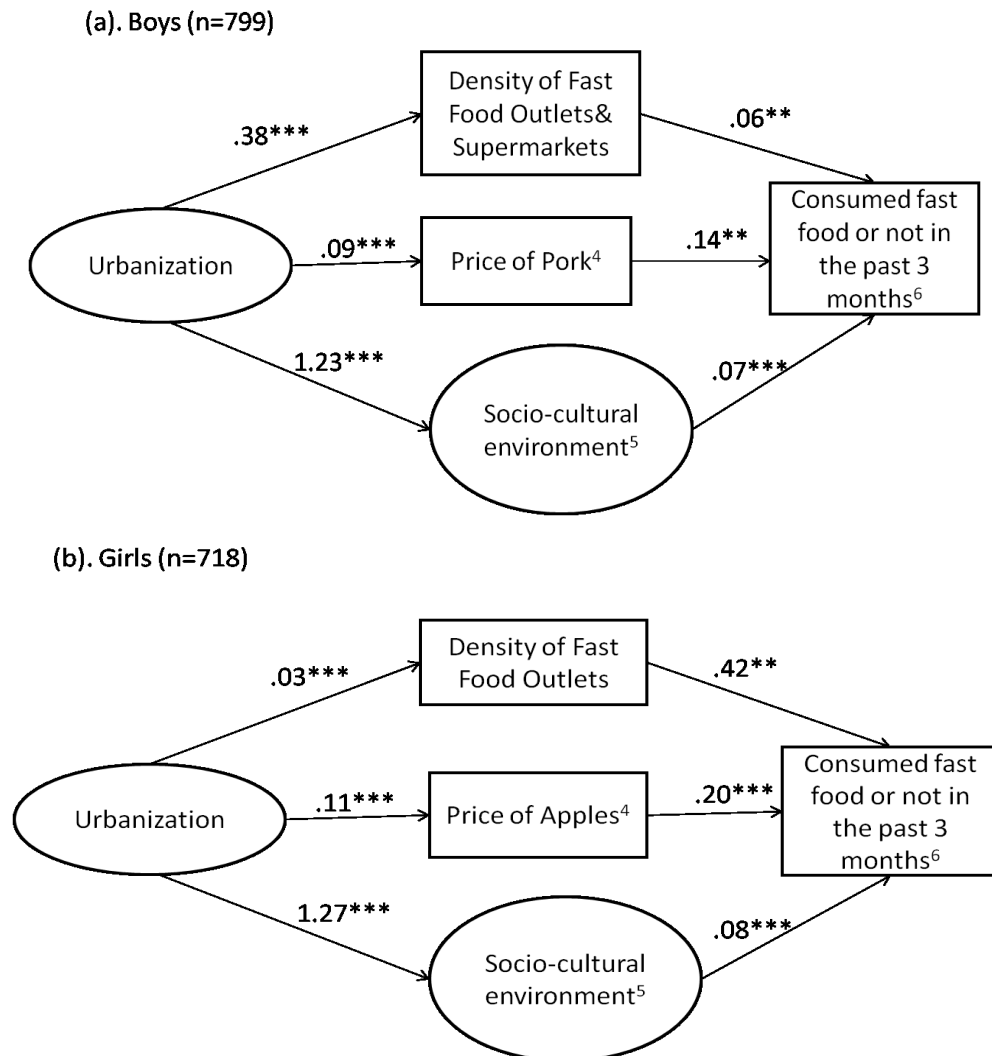
Mediation of the Food Environment between Urbanization and Western Fast Food Consumption

Figure 5.2 shows the results of mediation analyses where the outcome was the odds of having reported consuming Western FF or not in the past three months. The effect of urbanization on Chinese boys' Western FF consumption (dichotomous) was significantly mediated by three dimensions of the food environment: density of FF restaurants and supermarkets (indirect effect=0.02), price of pork (indirect effect=0.01) and the socio- cultural environment: community- level nutrition- knowledge and prevalence of FF preference (indirect effect=0.09).

The pattern was slightly different for girls: the density of FF restaurants (indirect effect=0.01), price of apples (indirect effect=0.02) and the socio-cultural environment (indirect effect=0.10) were found to mediate the relationship between urbanization and Western FF consumption.

Figure 5.2. The Relationship between Urbanization and Chinese Children's Western Fast Food Consumption (dichotomous) and Mediation of Food Environments based on Structural Equation Models to Study by Gender: CHNS

^{1,2,3}
2004-2011



* $p < 0.05$, ** $p < 0.01$ *** $p < 0.001$

¹ Based on data from children aged 6-18, who participated at least twice in the China Health and Nutrition Survey (CHNS) in 2004, 2006, 2009 and 2011;

² Based on results from generalized structural equation models (gsem). Each arrow stands for a regression coefficient from a three-level multi-level logistic regression analysis (children at different waves nested in communities) controlling for age, ethnicity, household income, mother's education and geographic regions when the outcome was Western fast food consumption, or controlling for study wave and geographic regions when the outcome were mediators.

³ Residual arrows were omitted.

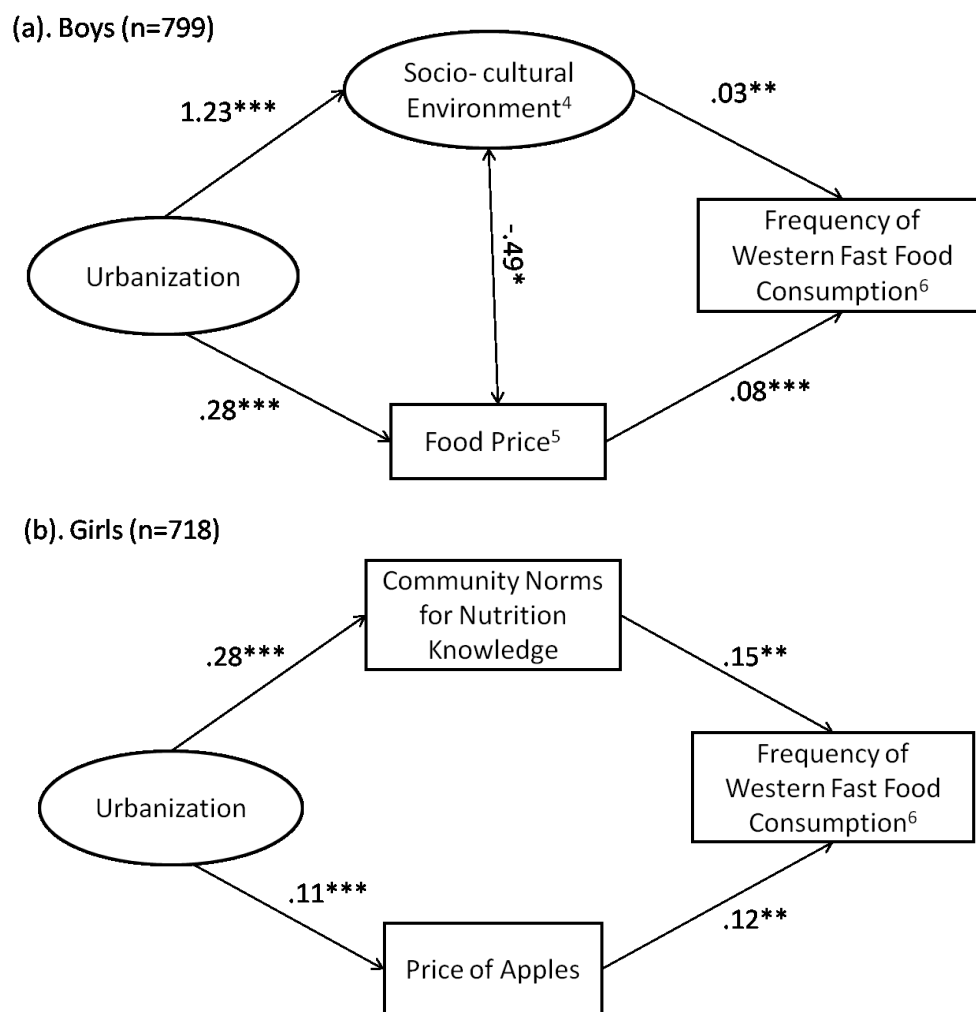
⁴ Food prices were inflated to the year 2011 values using consumer price index (CPI).

⁵ Indicators for the socio-cultural environment was obtained by summing up scores for the norms of fast food consumption preference and nutrition knowledge.

⁶ Having eaten at a Western fast food restaurant or not during the past 3 months.

Path diagrams showed different patterns when the outcome was the frequency of Western FF consumption (**Figure 5.3**). No evidence supported the mediation of the physical environment. Meanwhile, the socio-cultural environment (indirect effect= 0.04) and prices of apple and pork (indirect effect= 0.02) mediated the relationship between urbanization and Western FF consumption among boys, while community norms for nutrition knowledge (indirect effect=0.04) and the price of apples were found to be mediators among girls (indirect effect=0.01).

Figure 5.3. The Relationship between Urbanization and Chinese Children's Western Fast Food Consumption (continuous); Mediation of Food Environments based on Structural Equation Models, by Gender: CHNS 2004-2011^{1,2,3}



* $p < 0.05$, ** $p < 0.01$ *** $p < 0.001$

1 Based on data from children aged 6-18, who participated at least twice in the China Health and Nutrition Survey (CHNS) in 2004, 2006, 2009 and 2011;

2 Based on results from generalized structural equation models (gsem). Each arrow stands for a regression coefficient from a three-level multi-level linear regression analysis (children at different waves nested in communities) controlling for age, ethnicity, household income, mother's education and geographic regions when the outcome was Western fast food consumption, or controlling for study wave and geographic regions when the outcome were mediators.

3 Residual arrows were omitted.

4 Indicators for the socio-cultural environment was obtained by summing up scores for the norms of fast food consumption preference and nutrition knowledge.

5 Food prices were obtained by summing up prices of apple and pork, inflated to the year 2011 values using consumer price index (CPI).

6 Number of times eaten at a Western fast food restaurant during the past 3 months.

DISCUSSION

This study finds that the proportion of Chinese children reporting eating at a Western FF restaurant in the past three months rose from 15.9% in 2004 to 25.5% in 2011, a 60% increase. The consumption rate was higher among boys, urban residents, and adolescents compared to girls, rural residents, and younger children, respectively. Chinese children's Western FF consumption was closely related to the urbanicity level of their local communities. It was also related to the wider, larger geographic regions, even after controlling for urbanicity level. The association between urbanization and children's Western FF consumption was fully mediated by the food environment, especially by its economic and socio-cultural components. However, the patterns differed by gender.

We focused on children's Western FF consumption, as a potential risk factor for childhood obesity and it has been increasing over time (Rosenheck, 2008). The expansion of Western FF has also led to many changes in local food market. Although

a previous study conducted a latent class cluster model on 9,788 adults included in the 2006 CHNS and concluded that the association between FF consumption and obesity in China was weak, perhaps due to limited access to FF outlets, this may no longer be the case as FF outlets have become more and more accessible, as a result of urbanization and economic development (Wu et al., 2016; X. Zhang et al., 2012). In support of this, our current analyses show that the proportion of Western FF consumption among Chinese children aged six and above more than doubled from 2004 to 2011, while our previous study showed that Chinese children's Western FF consumption rose from 18.5% in 2004 to 23.9% in 2009 (Xue et al., 2016).

The Association between Urbanization and Western Fast Food Consumption

These findings support our hypothesis that urbanicity is positively associated with consumption of Western FF among Chinese children. It shows that children living in more urbanized communities were almost three times as likely to report having consumed Western FF in the past three months than those living in less urbanized communities.

Though very few studies have explored the association between urbanization and Western FF consumption in China, some did indicate a positive link between urbanization and a Westernized diet (S. W. Ng et al., 2008; Popkin, 1999, 2008; Zhai et al., 2014). A longitudinal study analyzed data from CHNS 1991- 2011 and reported a dramatic shift in dietary patterns and cooking behaviors in China accompanying urbanization. The typical Chinese diet has now shifted toward a more Westernized

diet, characterized by increased intake of refined grains, oils, animal- source foods, added sugars, snacks, processed foods and sugar-sweetened beverages (Su et al., 2015). In addition, food cooking methods have shifted from boiling and steaming to stir-frying, adding to daily calorie intake and percent energy from fat (Zhai et al., 2014). Another study using data from 14,976 participants aged two and above in CHNS 2011 found those living in the most urbanized areas obtained almost two fifths of their total energy intake from processed foods (Zhou et al., 2015). One case-control study examined 402 children aged 7 to 12 and found urban children from Guangzhou, the capital of Guangdong province, were more likely to eat a Westernized diet consisted of more milk, eggs, chocolate and cereals consumption, compared to their rural counterparts in Shaoguan, a county in the same province (Z. Yang et al., 2015).

The positive association between urbanicity and Chinese children's Western FF consumption could be explained in part by shifts in family composition and household income. Compared to Chinese families living in less urbanized areas, most of the families living in urban areas are nuclear families (in which grandparents do not live with their children and grandchildren) instead of extended families, and where mothers, as the primary caregivers to children, often must work full-time outside the home to support their families (Chunhua, Jinqun, Yinhe, Zhenyu, & Can, 2011; H. Liu, Wahl, Seale Jr., & Bai, 2015). Consequently, they lack the time to prepare food for their children, while their earnings add to total household income and provide more pocket money for children to eat convenient and quick Western FF (Cook & Dong, 2011; H. Liu et al., 2015).

The Mediation of the Food Environment between Urbanization and Western Fast Food Consumption

In addition to changes in family composition and household income, the mediating effects of the food environment also help to explain the underlying mechanisms of this association. Though some previous studies have tested the association between urbanization, food environment and Western FF consumption by Chinese children, none have checked the relationship of the three factors simultaneously. We previously examined 216 communities participating in CHNS 2004- 2009 and showed that more urbanized communities usually had better access to all types of food establishments (i.e., FF restaurants, other restaurants, supermarkets and free markets), higher prices of apples and pork, as well as stronger norms for FF preference and better nutrition knowledge (Wu et al., 2016). More urbanized cities had significantly more supermarkets and Western FF restaurants, as well as fewer small- and medium-sized markets, based on findings from an observational study in 12 cities across China (Liao et al., 2016).

No consensus has been reached regarding whether the food environment is related to children's dietary intake in China, and such evidence is quite limited. One study investigated 24,542 Chinese adults in CHNS 2004- 2011 and suggested increased food accessibility contributed to food diversity (J. Liu, Shively, & Binkley, 2014). Findings from developed countries are also inconsistent across systematic reviews and empirical studies (An & Sturm, 2012; Fraser et al., 2010; Galvez et al.,

2010; Moore et al., 2008). For example, a study of 13,462 children and adolescents from the 2005 and 2007 California Health Interview Survey reported no clear relationship between food environment and dietary intakes (An & Sturm, 2012). Another study of 801 Australian children in 2002-2003 showed a negative association between availability of FF outlets and children's vegetable and fruit intake (Timperio et al., 2008).

The reason for this inconsistency may be that previous studies focused exclusively on the physical environment (e.g., the availability of FF outlets) rather than on other dimensions of the food environment- the economic environment and socio- cultural environment. Our findings suggest some components of the socio-cultural and economic environments (e.g., price of pork or apples) in the ANGELO framework have played a more crucial role than the physical environment in affecting children's dietary patterns (Swinburn et al., 1999). With the widespread expansion of public transportation and increased ownership of private automobiles, the availability of food establishments around one's home is no longer the major concern when deciding where and what to eat, with perhaps food price and the norms for food having more impact on Chinese children's food choices. Furthermore, as a result of urbanization, children can easily access all types of food establishments, and more food options have become available. Thus, food prices and norms of FF preference may begin to have a greater effect.

The prices of apples and pork were positively associated with children's Western FF consumption. Though few such studies have been conducted in China,

prices of fruits and vegetables were found to be positively associated with improved dietary quality, based on data from 7,331 adults surveyed in the US Department of Agriculture Continuing Survey of Food Intakes by Individuals (CSFII 1994–96) (J. Liu et al., 2014), which substantiated our findings.

The discrepancy between greater nutrition knowledge and increased Western FF consumption is ironic, and may suggest that nutrition education did not emphasize the adverse health effects brought about by frequent Western FF consumption, a good thing to include in future health education programs.

Overall, findings from this study suggest employing multi- component prevention programs to reduce childhood obesity and non- communicable chronic disease, taking into account food prices, social norms as well as food accessibility. This lends support to our previous meta- analysis on childhood obesity preventions on developed countries, which calls for environmental- oriented interventions (Bleich, Segal, Wu, Wilson, & Wang, 2013; L Cai, Wu, Cheskin, Wilson, & Wang, 2014; Li Cai et al., 2014; Y. Wang et al., 2015).

The Association between Geographic regions and Western Fast Food Consumption

A regional dietary pattern appears to play a role in affecting Chinese children's Western FF consumption, even after adjusting for community urbanicity levels. Compared to children from South China, those living in Northeast China were more likely to have consumed Western FF, even if they lived in neighborhoods with similar

urbanicity levels and came from families with comparable SES. This suggests that despite the changes in lifestyles brought about by urbanization, some traditional dietary patterns in a specific region continue to affect the contemporary dietary intakes of residents living in those regions. This may help to explain the regional differences in rates of obesity and chronic diseases (JI & CHEN, 2013; Z. Yang et al., 2015).

Strengths and Weakness

This is the first longitudinal study to examine the impact of urbanization on Chinese children's FF consumption using nationwide survey data. It further studied the mediating effect of food environment in the causal pathway, and examined the mechanisms through which urbanization takes effect.

It also suffers from some limitations. First, analyses showed that children in this study were observed twice were different in terms of socio-demographics versus those who were observed only once. Thus, we need to be cautious when generalizing our results to the entire population of Chinese children. Second, community- level SES could possibly confound the relationship between urbanicity and Western FF consumption. However, one component of the urbanicity index- community economic status, overlaps with community- level SES and could be regarded as a substitute for community SES and thus has been adjusted for in our analyses. Finally, we treated urbanicity as a time- dependent variable, which could not explain how changes in urbanization result in changes in Western FF consumption. However, we conducted

additional analyses by dividing the effects of urbanization into two parts- the initial urbanization levels and change in urbanicity. Separate analysis of their associations with Western FF consumption were conducted. These findings yielded similar results as presented here, and thus are not shown.

In conclusion, our findings shed new light on the negative impacts of urbanization, and considers how changes- shifts on the food environment, and an increased Western FF consumption among Chinese children may be an important factor in obesity and health. Some public health implications may include: (1) Interventions at the policy and environment levels are needed to reduce Western FF consumption and improve diet quality in China, such as offering tasty and nutritious school meals to avoid dining out, and putting a limit on prices of some food items like apples; (2) Current nutrition education does not appear to have sufficiently conveyed information to the public the adverse effects of unhealthy diet including Western FF consumption on health and there is a need to deliver such message; and (3) Interventions should be tailored, e.g., by geographic regions, gender and age.

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CHAPTER 6: IMPACT OF URBANIZATION ON CHINESE CHILDREN'S WEIGHT STATUS: THE MEDIATING ROLE OF THE FOOD ENVIRONMENT

Abstract

Background and objectives: Research on how urbanization influenced Chinese children's weight status is limited. We studied the association between urbanization and childhood obesity in China and how the food environments mediated this relationship.

Methods: Longitudinal data collected during 2004- 2011 from the China Health and Nutrition Survey (CHNS). Urbanicity index was assessed using a scale (0- 10) for 10 components (population density, economic activity, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social service). Final analyses used random- effect models and structural equation modeling on data from 1,878 children aged 2- 18.

Results: Urbanicity was positively associated with increased risk of becoming overweight or obese among boys (OR=1.38, 95% CI: 1.13~1.67), but not girls. Among the ten components of urbanicity, only the community- level economic component was significantly related to childhood obesity risk (OR=1.11, 95% CI: 1.00~1.22). Some components of the food environment may have mediated this relationship, including density of fast food outlets, food prices for apples or flour, and community norms for nutrition knowledge.

Conclusions: Urbanization is associated with childhood obesity in China, but only

in boys, and this relationship is mediated by the food environment. These findings suggest that future childhood obesity prevention and intervention efforts could benefit from focusing on modifying the food environment and food pricing policies, as well as by tailoring interventions by gender.

Keywords: urbanization; food environment; childhood obesity; China; children

INTRODUCTION

The obesity epidemic has expanded in both developed and developing countries in recent years (Popkin et al., 2012; WANG & LOBSTEIN, 2006; Youfa Wang et al., 2006), and becomes a global epidemic. In the United States, the 2011-2012 *National Health and Nutrition Examination Survey* (NHANES) reported an obesity rate of 17% (or 12.7 million) among children and adolescents aged 2- 19 years (CL, MD, BK, & KM, 2012). China, the most populous country and the second largest economy in the world, is also suffering from an obesity epidemic. While obesity was uncommon in past generations in China, the *National Survey on the Constitution and Health of Chinese Students* showed 19.2% of school- age children were either overweight or obese in 2010 (JI & CHEN, 2013). Most recent 2012 national data reported that overall 43% of Chinese adults were overweight or obese.

While many factors contributing to this population shift, an important driver is the fast urbanization in China and associated changes. Since the 1990s, more and more rural families have moved to cities for work and educational opportunities, transforming what were previously villages, towns or cities into towns, cities, and mega- cities. Nowadays more than half of the Chinese population lives in urban areas,

and the fraction is still increasing (Chen, Liu, & Tao, 2013). A recent study compared urbanization in China to that in other countries globally, and found China's urbanization process has outpaced its economic growth since 2005. This may cause serious problems if the trend continues, such as increased air temperature, decreased cultivated lands, easier access to Western fast food (FF) outlets, as well as poorer health (Cui & Shi, 2012; Van de Poel et al., 2012; Wu et al., 2016). Policy makers need to design strategies to promote health in the face of these changes related to urbanization (Chen et al., 2013).

Abundant evidence supports a positive link between urbanization and childhood obesity in China (JI & CHEN, 2013; Song, Wang, Ma, & Wang, 2013). The *National Survey on the Constitution and Health of Chinese Students* interviewed 297,062 school- aged children in 2010 and found 32.6% of the boys and 19.1% of the girls in large coastal cities were either overweight or obese, while the prevalence was only 8.2% and 5.3% for those living in rural, western regions (JI & CHEN, 2013).

Urbanization in China has also brought dramatic changes to the *food environment* that children live in. For example, a Westernized diet symbolized by Western FF has become more available, affordable and acceptable to Chinese children in urban areas (Wu et al., 2016). In addition to FF outlets, other types of restaurants, supermarkets and open- air markets are more available in urban as compared to rural areas, providing more food options to children living there (Wu et al., 2016). Urbanization has also been accompanied by lower prices for edible oils, which are used in part to cook animal- based foods, thus contributing to higher fat intake (Ng et

al., 2008). It was also found to be related to higher prices for apples ($\beta=0.06$, 95% CI: 0.04-0.08) and lean pork ($\beta=0.02$, 95% CI: 0.01-0.03)(Wu et al., 2016).

There is as yet no clear scientific consensus regarding the connections between the food environment and childhood obesity(Bleich et al., 2013; Li Cai et al., 2014; Galvez et al., 2010; Lee, 2012; Rahman et al., 2011; Shier et al., 2012; Swinburn et al., 2016). The evidence base in China regarding this connection is sparse. Just one paper by Zhang, Lans and Dagevos suggested a link between food retail environment and a higher body mass index (BMI) by surveying 9,788 adults participating in the 2006 China Health and Nutrition Survey (CHNS) (Zhang et al., 2012). However, it has not explored this relationship using a nationwide, longitudinal dataset. To date, no study has examined the role the food environment plays in the link between urbanization and childhood obesity.

Using a nationwide longitudinal dataset, this study examined the relationship between urbanization and children's weight status in China, and tested whether the relationship was mediated by three different dimensions of the community- level food environment: (1) the local food environment (the physical environment); (2) community- level food prices (the economic environment); and (3) community norms for nutrition knowledge, FF preferences and FF consumption (community- level socio- cultural environment).

MATERIALS & METHODS

Study Design and Sample

This study used a nationwide, longitudinal dataset from the CHNS collected in four consecutive waves: 2004, 2006, 2009 and 2011 among children 2- 18 years old across the four study waves. The final sample included 1,819 children from 217 communities, who were followed at least twice among the surveys conducted between 2004 and 2011, with complete data on BMI. The follow- up rate was 44.7%. Compared to children finally included in the study, those who were excluded tended to be older, more likely to be non- overweight/obese, of Han ethnicity, and from families with higher mother's education levels. They were more likely to be living in more urbanized communities with better access to all types of food outlets except free markets, with higher food prices and stronger norms for FF and nutrition (**Appendix 6.A**).

Appendix 6.A: Comparisons of Baseline Characteristics between Children Included and Excluded in the Study: CHNS 2004-2011 (N=4073)^{1,2,3}

	Excluded (n=2254) Mean (SD)	Included (n=1819) Mean (SD)	Sig
CHILD AND HOUSEHOLD CHARACTERISTICS			
overweight/obese, n (%) ⁴	184 (8.2)	223 (12.3)	***
age	9.79 (5.2)	7.73 (4.0)	***
girl, n (%) ⁴	1057 (46.9)	837 (46.0)	
Han ethnicity, n (%) ⁴	1995 (88.8)	1508 (83.0)	***
Mother's education, n (%) ⁴			
<High school	1151 (64.0)	1235 (79.8)	
High school/vocational	393 (21.9)	261 (16.9)	
College& master	254 (14.1)	52 (3.4)	***
Household income, n (%) ^{4,5}			
Low	710 (32.0)	614 (34.1)	
Medium	756 (34.1)	628 (34.8)	
High	752 (33.9)	561 (31.1)	
COMMUNITY CHARACTERISTICS			
Urbancity index (range 0-10)	5.92 (1.73)	5.06 (1.53)	***
Urban, n (%) ⁴	821 (36.4)	494 (27.2)	***
FOOD ENVIRONMENT			
	Median (IQR)	Median (IQR)	
(1) Physical environment			
<i>Density (# per 1,000 residents)</i>			

fast food restaurant	0.09 (0)	0.12 (0)	*
other indoor restaurant	2.87 (2.82)	3.94 (4.10)	
supermarket	0.94 (1.00)	1.25 (1.44)	*
free market	2.27 (1.64)	2.04 (1.73)	
<i>Proximity (Distance to the nearest such outlet in kilometers)</i>			
supermarket	5.45 (4.5)	5.71 (6)	**
free market	6.49 (3.5)	11.44 (10)	***
<i>Availability (n, % available)⁴</i>			
fast food restaurant	690 (30.7)	288 (16.0)	***
other indoor restaurant	1573 (70.3)	1194 (66.7)	*
supermarket	1355 (60.6)	1015 (56.8)	*
free market	821 (92.0)	1291 (92.1)	**
	Mean (SD)	Mean (SD)	
(2) Economic food environment(in Chinese Yuan/500 grams)⁶			
price for most commonly eaten rice	1.61 (0.47)	1.40 (0.27)	***
price for unbleached flour	1.60 (0.69)	1.44 (0.60)	***
price for soybean oil	5.28 (2.35)	4.61 (1.51)	***
price for most commonly eaten vegetable	1.06 (0.82)	0.86 (0.68)	***
price for apples	2.88 (2.54)	1.83 (0.94)	***
price for fatty& lean pork	9.37 (3.41)	7.76 (1.54)	***
(3) Socio-cultural environment			
prevalence of fast food consumption (%)	3.25 (3.68)	2.03 (2.94)	***
prevalence of fast food preferences (%)	6.90 (6.31)	4.87 (4.93)	***
average score for nutrition knowledge (0-12)	8.43 (0.92)	8.21 (1.03)	***

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ for comparisons between different weight status groups; obtained from ANOVA tests for normal data, Wilcoxon-Mann Whitney test for non-normal data, and chi-squared test for categorical data.

1 Results from the China Health and Nutrition Survey (CHNS) in 2004. Children were included if they aged 2-18 and participated at least twice in 2004-2011.

2 BMI was calculated from measured weight and height, and categorized using the IOTF cutoffs for children.

3 Mean and SD used for normal data; median and inter-quartile range (IQR) used for non-normal data; n and % used for categorical data.

4 % stands for column %. For example, among included children, 27.2% lived in urban areas.

5 Household income was defined as income per capita, deflated to the 2004 year values and trichotomized into low/medium/high groups for each wave.

6 Free market prices were used. If free market prices were not available, large state store prices were used; prices were deflated to 2004 year values using consumer price index (CPI).

The CHNS is a household- based, ongoing, open- cohort survey which started in 1989. It was conducted following a multi- stage, random cluster sampling scheme. It covers nine provinces across China: Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guangxi, Guizhou, and Heilongjiang provinces. Three municipal cities (Beijing, Shanghai and Chongqing) joined CHNS in 2011, but were not included in our current analyses because they were only followed once up to 2011. Those provinces and cities represent a wide range of geographic and socio- demographic regions across China.

The CHNS includes individual and household, as well as community components. Communities surveyed were urban and suburban neighborhoods, townships, and rural villages. Surveyors visited randomly- selected households in representative neighborhoods to conduct face- to- face interviews for the individual and household surveys. The community survey was largely based on interviews of community leaders or vendors (Popkin et al., 2010a).

Outcome: Children's Weight Status

Children's weight status is the primary outcome of interest. Weight was measured without clothes and shoes using SECA floor scales to the nearest 0.1 kg, and height measured with SECA stadiometers to the nearest 0.1cm by trained physicians and nurses. Weight and height were calculated to obtain BMI as the weight (kg)/ height² (m). The weight status of children over 24 months of age was divided into two categories: overweight or obese, and neither (i.e., normal or underweight)

using the new International Obesity Task Force (IOTF) BMI cutoffs for children (Cole & Lobstein, 2012a). The IOTF BMI cutoffs were built on representative data from six countries, and were linked to adult BMI cutoffs (Cole & Lobstein, 2012b). They are widely used in international comparisons, and showed similar results as the Centers for Disease Control and Prevention (CDC) growth charts and the World Health Organization (WHO) growth references (Li et al., 2016).

Exposure: Urbanicity Index

This study used an adapted version of an urbanicity scale developed based on CHNS data and exhibited good measurement quality (Jones-Smith & Popkin, 2010). This analysis removed two elements of the urbanicity index (the traditional market and modern market) out of the original twelve-item scale, as they overlapped with some components of the food environment as the mediator to be studied. Thus, the final urbanicity scale included ten elements (population density, economic activity, transportation infrastructure, sanitation, communications, housing, education, diversity, health infrastructure, and social services), and each scored from zero to ten.

The final urbanicity index (0-10, higher scores indicating higher urbanicity levels) was obtained by averaging the scores for the ten elements. It was treated as a continuous variable in our analyses.

Factor analysis indicated this adapted urbanicity scale was uni-dimensional, and can successfully distinguish the four official community types, with urban neighborhoods showing the highest urbanicity index, followed by towns, suburbs and

villages(Wu et al., 2016).

Mediator: Food Environment

This study hypothesized that the community- level obesogenic food environment mediates the relationship between urbanicity and children's weight status. It has three different dimensions: (1) the physical food environment, (2) the economic food environment, and (3) the socio- cultural food environment, as defined in the ANalysis Grid for Environments Linked to Obesity (ANGELO) framework (Swinburn et al., 1999).

Physical Food Environment

It was the conventional local food environment, taking into account four different types of the food retail and service establishments:

- (1) FF restaurants (mostly Western franchise restaurants, e.g. McDonald's®, KFC®);
- (2) Other indoor restaurants;
- (3) Supermarkets;
- (4) Free markets (open- air markets).

It incorporated three types of indicators for each of the four food outlets types:

- (1) Availability: whether there were any food establishments in the neighborhood for FF restaurants or other indoor restaurants, or within 30

minutes' bus ride from the neighborhood for supermarkets and free markets (e.g., availability of FF restaurants);

(2) Density: the number of food establishments per 1,000 residents (e.g., density of supermarkets);

(3) Proximity: distance to the nearest food establishment in kilometers (e.g., proximity to the nearest free markets).

We only included density in our regression and structural equation modeling (SEM) analyses as this indicator contained more information and had fewer missing data points.

Economic Food Environment

It was measured by the prices of foods available in the community. Free market food prices for some typical food items were collected from vendors or salespersons inside each community. Prices for grains (rice, unbleached flour), cooking oils (soybean oil), vegetables (the most commonly consumed vegetables), fruits (apples) and meat (fatty & lean pork) were examined, all of which were typical foods consumed by Chinese families and may be linked to obesity or protection against obesity.

Consumer price index (CPI) was obtained from the National Bureau of Statistics of China (National Bureau of Statistics of China, 2014). CPIs are different by provinces or mega-cities, and are also different for urban and rural residents living in the same province or mega-city. However, CPIs reported here were constructed based

the previous year values. Thus, I adjusted CPI using the 2004 year value as base. For example:

$$A_CPI_{j,2006}=CPI_{j,2005}*CPI_{j,2006}$$

A_CPI_{2006} : Adjusted CPI in community j in the year 2006;

$CPI_{j,2005}$: CPI in community j in the year 2005;

$CPI_{j,2006}$: CPI in community j in the year 2006.

Prices in waves other than 2004 were deflated to the 2004 year values for better comparisons, based on each community's adjusted CPI. For example, for Community "j":

$$I_Price_{j,2006}=Price_{j,2006}\div A_CPI_{j,2006}$$

$I_Price_{j,2006}$: food prices in community j in the year 2006, deflated to the 2004 values;

$Price_{j,2006}$: actual food prices in community j in the year 2006;

$A_CPI_{j,2006}$: Adjusted CPI in community j in the year 2006.

Imputations for food prices included the following two steps: First, if free market prices were unavailable or were too extreme (unreasonably large or small), large-store prices were used. Second, if still missing or had extreme values, they were replaced with that wave's province- average.

Socio- cultural Food Environment

It was measured by community norms for nutrition knowledge, FF preferences, and FF consumption. As the question on FF consumption was only responded by children aged 6 to 18, community norms for FF consumption were aggregated from individual children's responses (aged 6- 18) from each community, while community norms for nutrition knowledge and FF preferences were aggregated from individuals' responses (aged 12 and above) from each community as they were answered by individuals within that age group.

A sample question was: *“During the past 3 months, how many times have you eaten at a Western FF restaurant, such as McDonald's® or Kentucky Fried Chicken®?”* Indicators for community norms included the mean score of nutrition knowledge for all surveyed individuals (aged 12 and above), fraction of individuals (aged 12 and above) preferring FF, and the fraction of children (aged 6- 18) who had consumed any FF in the past three months in the community.

Covariates

Child gender was considered as a potential effect modifier. Thus, analyses were conducted separately by gender.

Potential confounders in the relationship between the urbanicity index and children's weight status may stem from different levels, including community- level (geographical regions), household- level (family socio- economic status as reflected in per capita household income and mother's education levels), and individual- level

(child's age, ethnicity (Han or not)). Study wave was treated as a dummy variable and was also included in the models.

Statistical Analysis

All analyses were conducted using STATA 14.0 (StataCorp, 2015). Chi- squared tests for categorical data and ANOVA (Analysis of Variance) tests for continuous data were conducted to compare baseline characteristics (the first observations) between children who were either overweight or obese, versus those who were not.

Individuals in different waves were nested within communities. Household- level clustering was not taken into account because there were very few children from the same households, a result of the one- child policy in China which started in the late 1970s.

We fit three- level logistic regressions with a child- specific and a community- intercept intercept to examine the effects of urbanization on children's weight status. Analyses were conducted separately for boys and girls, after controlling for the community-, household- and individual- level covariates. The general logistic model is shown below:

$$\text{logit}(WS=1)_{ijt} = \beta_0 + \beta_1 * \text{urban}_{jt} + \beta_2 * \text{com}_j + \beta_3 * \text{hh}_{ijt} + \beta_4 * \text{ind}_{ijt} + \beta_5 * \text{wave} + b_{0i} + b_{1i} + \varepsilon$$

where i =child i , j =community j , t =wave t (wave 2004 when $t=0$, 2006 when $t=1$, 2009 when $t=2$, 2011 when $t=3$); WS = weight status, urban =urbanicity index, com =other community- level variables (geographical regions), hh =household- level

variables, ind=individual- level variables, wave=dummy variables for study waves, b_{0i} =child- specific intercept, b_{1i} =community- specific intercept, ε =error terms.

Similarly, we conducted multi- level modeling for BMI z-score as a continuous outcome to test the association between urbanization and children's BMI z-scores. The general logistic model is shown below:

$$zBMI_{ijt} = \beta_0 + \beta_1 * urban_{jt} + \beta_2 * com_j + \beta_3 * hh_{ijt} + \beta_4 * ind_{ijt} + \beta_5 * wave_t + b_{0i} + b_{1i} + \varepsilon$$

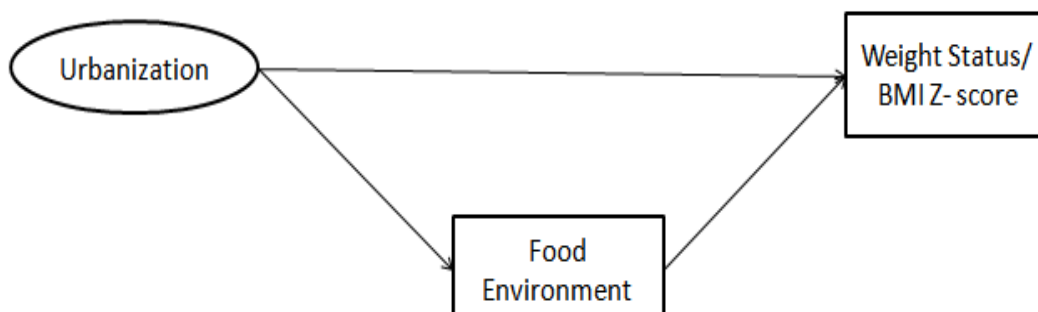
where i =child i , j =community j , t =wave t (wave 2004 when $t=0$, 2006 when $t=1$, 2009 when $t=2$, 2011 when $t=3$); $zBMI$ = bmi z-score, $urban$ =urbanicity index, com =other community- level variables (geographical regions), hh =household- level variables, ind =individual- level variables, $wave$ =dummy variables for study waves, b_{0i} =child- specific intercept, b_{1i} =community- specific intercept, ε =error terms.

Later, we changed the predictors to be the ten separate components of urbanicity to examine the association between the ten components of urbanicity and children's weight status or BMI z- scores.

We also examined mediation effects of the three dimensions of food environment on the pathway from urbanization to children's weight status or BMI z-scores across all study waves using STATA's `gsem` (generalized structural equation model (SEM)) command (see **Appendix 6.B** for analytic models). Firstly, we put the potential mediators (indicators of food environment) into our generalized SEM one at a time (e.g., only the density of FF outlets as mediator), fitting similar multi-level models as above. Then we kept those statistically significant indicators in our final SEM to check how the impact of urbanization of children's weight status or BMI z-scores was

mediated by food environment. Arrows were removed if regression coefficients were insignificant.

Appendix 6.B. Analytic Models to Study the Relationship between Urbanization and Chinese Children's Weight Status/ BMI z- scores and Mediation of Food Environments: CHNS 2004-2011^{1,2,3,4}



Models: analyses by gender

$$\text{logit}(WS=1)_{ijt} / \text{zbmi}_{ijt} = \beta_0 + \beta_1 * \text{urban}_{jt} + \beta_2 * \text{cov} + b_{0i} + b_{1i} + \varepsilon$$

Where j =child i , j =community j , t =study wave; WS = weight status, $zbmi$ =BMI z-score; urban =urbanicity index, cov =covariance, b_{0i} =child- specific intercept, b_{1i} =community-specific intercept, ε =error terms.

Covariates:

- (1) When outcome is weight status/ BMI z- score: age, ethnicity, household income, mother's education, geographical region;
- (2) When outcome is food environment: geographical region, study wave.

RESULTS

Baseline Characteristics

At baseline, from a total sample of 1819 children, 8.63% were overweight and an additional 3.63% were obese; thus, overweight and obese children were combined into a single group.

Overweight or obese children were more likely to live in more urbanized communities (urbanicity index: 5.47 [SD: 1.53] versus 5.01 [SD: 1.52], $p < .001$), closer to free markets (median: 6.62 kilometers [IQR: 5 kilometers] vs. 12.10 kilometers [IQR: 10 kilometers], $p < .01$), with greater availability (74.2% vs. 65.6%, $p < .05$) or higher density of other indoor restaurants (median: 5.30 [IQR: 5.49] vs. 3.74 [IQR: 3.78] restaurants per 1,000 residents, $p < .01$).

Overweight or obese children also tended to live in places with higher prices for rice (1.34 [SD: 0.19] vs. 1.31 [SD: 0.207] Chinese yuan/ 500 grams (g), $p<.05$), greater levels of preference for (5.51% vs. 4.78%, $p<.05$) and consumption of FF (2.81% vs. 1.92%, $p<.001$), and be more knowledgeable about diet and nutrition (average score 8.59 [SD: 1.00] vs. 8.16 [SD: 1.03], $p<.001$).

They tended to be younger (6.58 [SD: 3.52] vs. 7.73 [SD: 3.98] years old, $p<.001$), more likely to be of Han ethnicity (87.9% vs. 82.3%, $p<.05$) and from families with higher maternal education levels ($p<.01$).

Table 6.1: Baseline Community-, Household- and Child-level Characteristics by Children's Weight Status: CHNS 2004-2009^{1,2}

	Weight Status ³			
	All (n=1819)	Normal/underweight	Overweight/obese	
	Mean (SD)	(n=1596)	(n=223)	
		Mean (SD)	Mean (SD)	Sig
CHILD AND HOUSEHOLD CHARATERISTICS				
age	7.59 (3.94)	7.73 (3.98)	6.58 (3.52)	***
girl, n (%)	837 (46.0)	748 (46.9)	89 (39.9)	
Han ethnicity, n (%)	1509 (83.0)	1313 (82.3)	196 (87.9)	*
Mother's education, n (%)				
<High school	1350 (81.0)	1194 (82.1)	156 (73.9)	
High school/vocational	262 (15.7)	221 (16.2)	41 (19.4)	
College& master	54 (3.2)	40 (2.8)	14 (6.6)	**
Household income, n (%) ^{4,5}				
Low	614 (34.1)	555 (35.0)	59 (26.9)	
Medium	628 (34.8)	546 (34.5)	82 (37.4)	
High	561 (31.1)	483 (30.5)	78 (35.6)	
COMMUNITY CHARACTERISTICS				
Urbancity index (range 0-10)	5.06 (1.53)	5.01 (1.52)	5.47 (1.53)	***
Urban, n (%) ⁵	494 (27.2)	410 (25.7)	84 (37.7)	***
	Median (IQR)	Median (IQR)	Median (IQR)	
FOOD ENVIRONMENTS				
(1) Physical food environment				

<i>Density (# per 1,000 residents)</i>				
fast food restaurant	0.12 (0)	0.11 (0)	0.22 (0)	
other indoor restaurant	3.94 (4.10)	3.74 (3.78)	5.30 (5.49)	**
supermarket	1.25 (1.44)	1.25 (1.44)	1.32 (1.43)	
free market	2.04 (1.73)	2.07 (1.73)	1.82 (1.62)	
<i>Proximity (Distance to the nearest such outlet in kilometers)</i>				
supermarket	5.71 (6)	5.80 (6.2)	5.07 (3.9)	
free market	11.44 (10)	12.10 (10)	6.62 (5)	**
<i>Availability (n, % available)⁵</i>				
fast food restaurant	288 (15.9)	249 (15.7)	39 (17.6)	
other indoor restaurant	1194 (66.7)	1030 (65.6)	164 (74.2)	*
supermarket	1015 (56.8)	891 (56.9)	124 (56.4)	
free market	1291 (92.1)	1141 (92.4)	150 (89.8)	
	Mean (SD)	Mean (SD)	Mean (SD)	
(2) Economic food environment(in Chinese Yuan/500 grams)⁶				
price for most commonly eaten rice	1.31 (0.20)	1.31 (0.20)	1.34 (0.19)	**
price for unbleached flour	1.36 (0.56)	1.37 (0.56)	1.29 (0.53)	
price for soybean oil	4.30 (1.35)	4.31 (1.35)	4.21 (1.41)	
price for most commonly eaten vegetable	0.81 (0.62)	0.81 (0.64)	0.78 (0.51)	
price for apples	1.70 (0.78)	1.70 (0.78)	1.67 (0.88)	
price for fatty& lean pork	7.31 (1.61)	7.32 (1.65)	7.24 (1.29)	
(3) Socio-cultural food environment				
prevalence of fast food consumption (%)	2.03 (2.94)	1.92 (2.84)	2.81 (3.43)	***
prevalence of fast food preference (%)	4.87 (4.93)	4.78 (4.89)	5.51 (5.23)	*
average score for nutrition knowledge (0-12)	8.21 (1.03)	8.16 (1.03)	8.59 (1.00)	***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ to test if any differences by weight status using chi-squared tests for categorical data or ANOVA for continuous data.

1 Results from the first round of observations for children, who were followed at least twice in the China Health and Nutrition Survey (CHNS) 2004- 2011.

2 Mean and SD used for normally distributed data; median and inter-quartile range (IQR) used for non-normally distributed data; n and % used for categorical data.

3 BMI was calculated from measured weight and height, and was categorized into weight status groups using the age- and sex-specific IOTF cutoffs for children.

4 Household income was defined as income per capita, inflated to the 2011 year values and trichotomized into low/medium/high groups for each wave.

5 % stands for column %. For example, among overweight/obese children, 37.7% lived in urban areas.

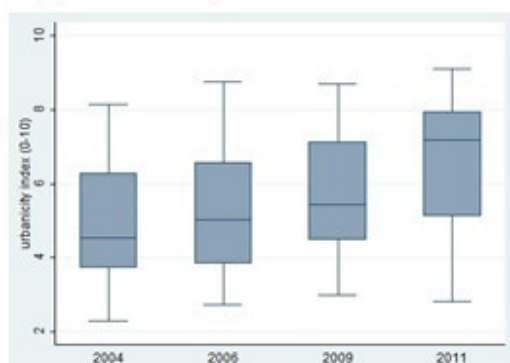
6 Free market prices were used. If free market prices were not available, large state store prices were used. If still missing, province-average in that wave was used. Prices were deflated to the year 2004 values using consumer price index (CPI).

Time Trends in Urbanicity and Food Environment

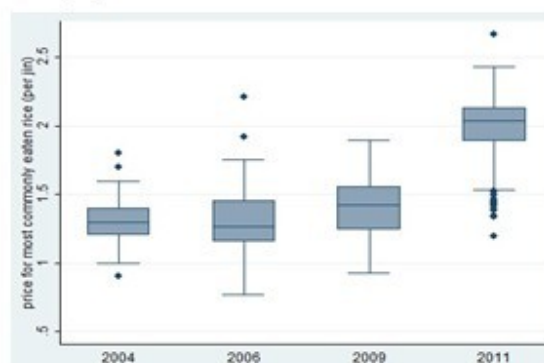
Figure 6.1 shows time trends in urbanicity index and indicators of the food environment. Almost all indicators increased with succeeding study waves, except for a slight decline in 2006 for prices of flour and pork.

Figure 6.1 Time Trends in Urbanicity Index and Food Environment: CHNS 2004-2011^{1,2}

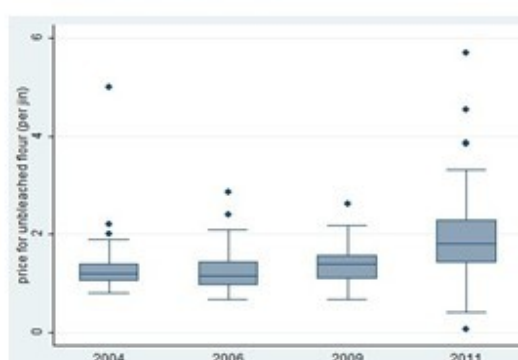
(a). Urbanicity Index



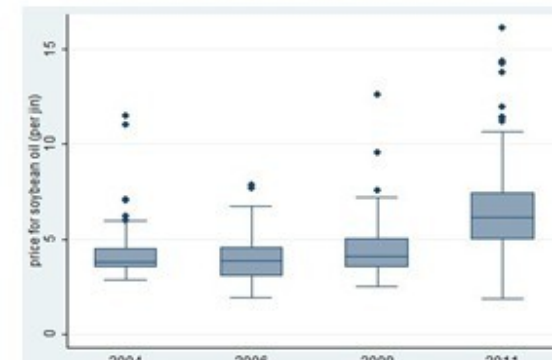
(b). Price of Rice



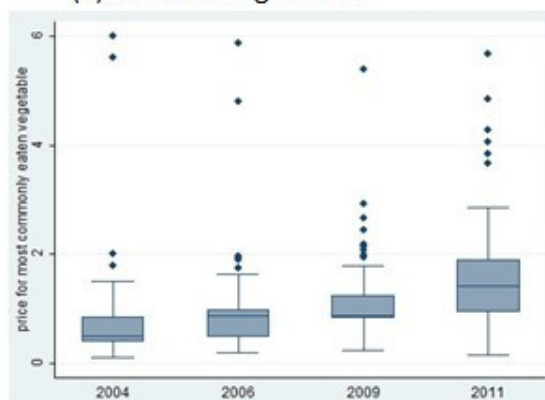
(c). Price of Flour



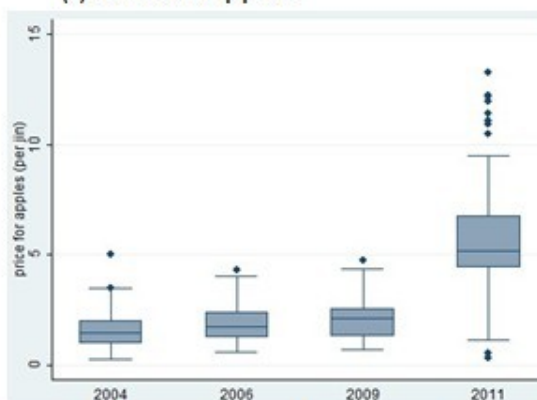
(d). Price of Soybean Oil



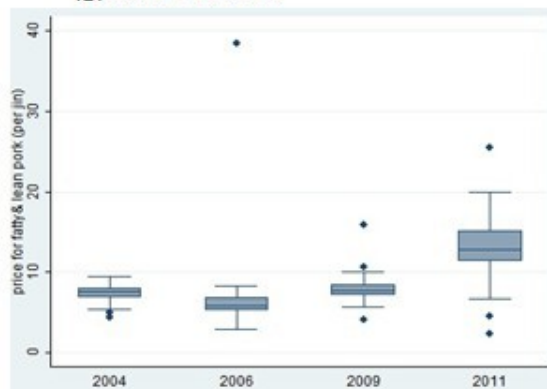
(e). Price of Vegetables



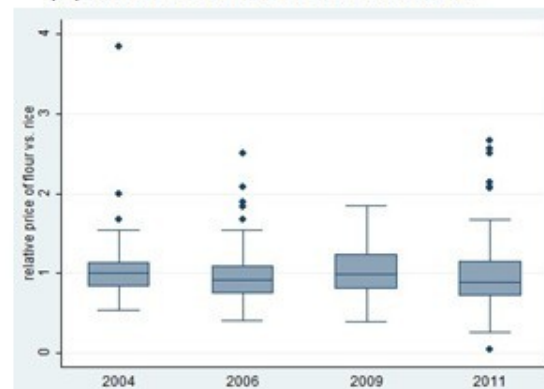
(f). Price of Apples



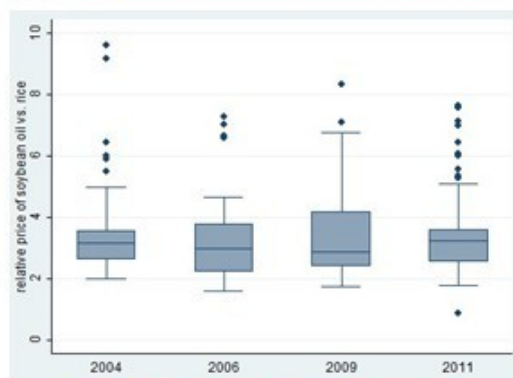
(g). Price of Pork



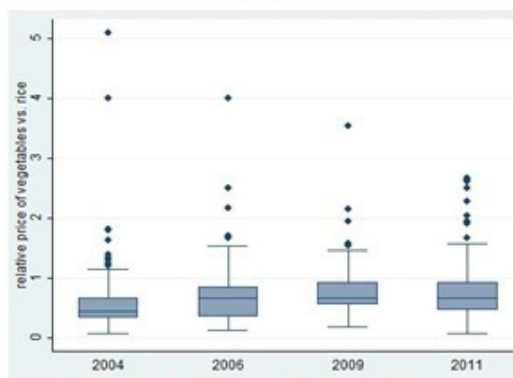
(h). Relative Price of Flour vs. Rice



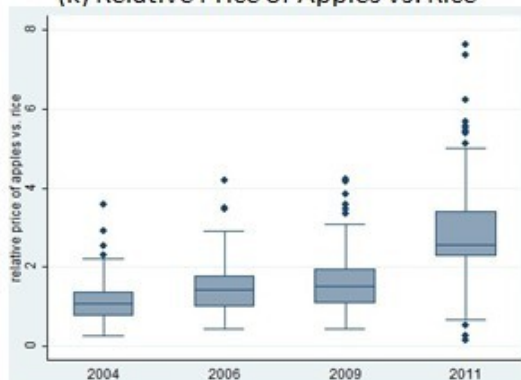
(i). Relative Price of Soybean Oil vs. Rice



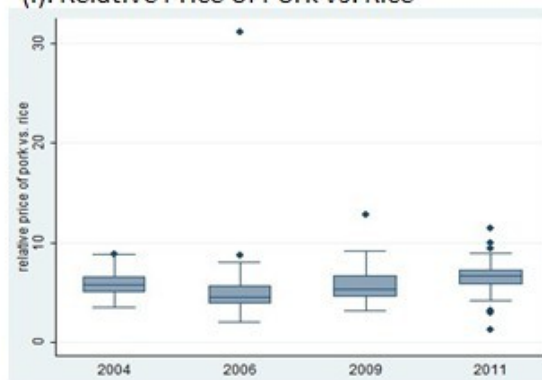
(j). Relative Price of Vegetables vs. Rice



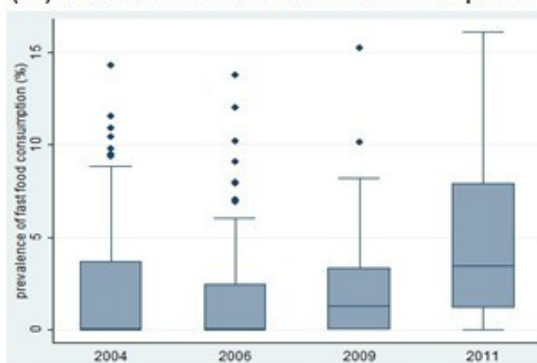
(k) Relative Price of Apples vs. Rice



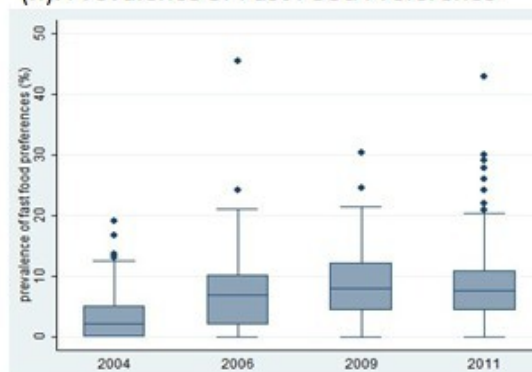
(l). Relative Price of Pork vs. Rice



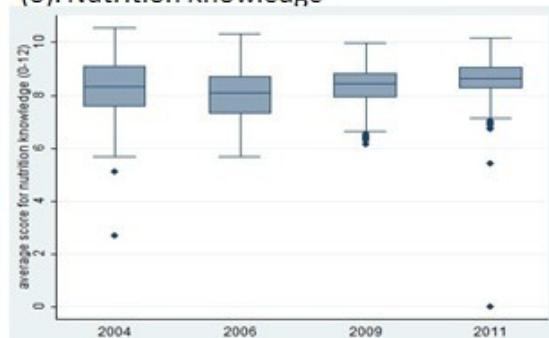
(m). Prevalence of Fast Food Consumption



(n). Prevalence of Fast Food Preference



(o). Nutrition Knowledge



¹ Based on data from children aged 2-18, who participated in the China Health and Nutrition Survey (CHNS) in 2004, 2006, 2009 and 2011.

² Food prices were deflated to the year 2004 values using consumer price index (CPI).

The Association between Urbanization and Weight Status, BMI Z- score

Table 6.2 shows the results of multi- level logistic regressions to examine the association between urbanization and its components and Chinese children's weight status from 2004 to 2011, controlling for age, ethnicity, household income, mother's education, geographical regions and study waves. Significant findings were only found among boys. Living in more urbanized communities was associated with increased odds of being overweight or obese in boys (OR=1.38, 95% CI: 1.14, 1.68). Community economic status also increased the chance of being overweight or obese in boys (OR=1.11, 95% CI: 1.00, 1.22).

Results of multi- level linear regression analyses to examine the association between urbanization and its components and Chinese children's BMI z-scores in 2004- 2011 are also shown. Though similar patterns were observed, none of these results reached statistical significance.

Table 6.2: Multi- level Regressions to Examine the Association Between Urbanization or Its Components and Chinese Children's Weight Status or BMI z-scores by Gender: CHNS 2004-2011^{1,2,3}

	Overweight/obese vs. not ²						BMI z-score ³					
	Boys (n=1011)			Girls (n=867)			Boys (n=1011)			Girls (n=867)		
	OR	95% CI	sig	OR	95% CI	sig	beta	95% CI	sig	beta	95% CI	sig
<i>Model 1: Urbanicity as predictor</i>												
Urbanicity	1.38	1.14, 1.68	**	1.05	0.84, 1.30		0.04	-0.00, 0.09		0.01	-0.03, 0.06	
<i>Model 2: Ten components of urbanicity as predictor</i>												
population density	0.98	0.77, 1.26		1.01	0.76, 1.33		-0.01	-0.06, 0.03		-0.02	-0.07, 0.03	
education	0.87	0.61, 1.22		1.04	0.69, 1.56		0.06	-0.00, 0.13		0.02	-0.06, 0.09	
sanitation	0.98	0.85, 1.14		1.18	0.98, 1.41		-0.00	-0.03, 0.02		0.02	-0.01, 0.05	
housing	1.09	0.87, 1.35		0.89	0.68, 1.16		0.02	-0.01, 0.06		-0.01	-0.05, 0.04	
transportation	1.04	0.83, 1.16		1.12	0.98, 1.28		-0.01	-0.03, 0.01		0.01	-0.01, 0.03	
communication	1.16	0.93, 1.44		0.86	0.67, 1.10		0.03	-0.01, 0.06		-0.01	-0.05, 0.03	
health	0.96	0.86, 1.07		1.01	0.89, 1.15		-0.00	-0.02, 0.01		0.00	-0.02, 0.02	
economy	1.11	1.00, 1.22	*	1.09	0.96, 1.23		0.01	-0.01, 0.03		0.01	-0.01, 0.03	
diversity	1.01	0.74, 1.38		0.85	0.59, 1.23		-0.03	-0.08, 0.03		-0.02	-0.08, 0.04	
social service	1.07	0.97, 1.18		0.94	0.84, 1.06		0.00	-0.01, 0.02		-0.02	-0.04, 0.00	

* p<0.05, ** p<0.01 *** p<0.001

1 Based on data from children aged 2- 18, who participated at least twice in the China Health and Nutrition Survey (CHNS) in 2004, 2006, 2009 and 2011.

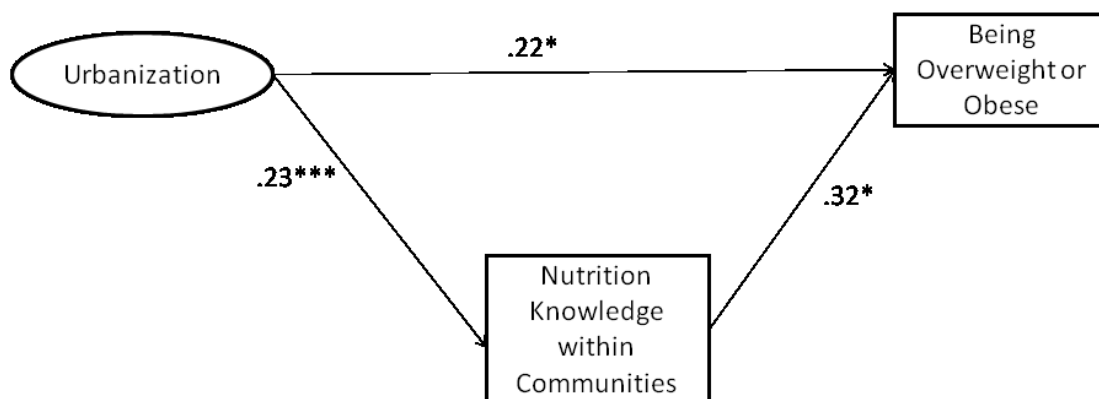
2 Based on mixed- effect logistic regression models (xtmelogit) with child- and community- specific intercepts, controlling for age, ethnicity, household income, mother's education, geographical regions and study waves.

3 Based on mixed- effect linear regression models (xtmixed) with a child- and community- specific intercept, controlling for age, ethnicity, household income, mother's education, geographical regions and study waves.

Food Environments as Mediators

Figure 6.2 shows results of mediation analyses between urbanization and children's weight status. It suggests that urbanization not only had a direct positive effect on boys' odds of being overweight or obese (regression coefficient=0.22, $p<.05$), but also contributed to it indirectly, through community norms for nutrition knowledge (indirect effect=0.007). However, no such mediation effect was found among girls.

Figure 6.2. The Relationship between Urbanization and Chinese boys' Weight Status; Mediation of Food Environments based on Structural Equation Models, by Gender: CHNS 2004-2011^{1,2,3}



* $p<0.05$, ** $p<0.01$ *** $p<0.001$

¹Based on data from boys aged 2-18, who participated at least twice in the China Health and Nutrition Survey (CHNS) in 2004, 2006, 2009 and 2011.

²Based on results from generalized structural equation models (*gsem*). Each arrow stands for a regression coefficient from a three-level multi-level logistic regression analysis (children at different waves nested in communities) controlling for age, ethnicity, household income, mother's education and geographical regions when the outcome was weight status, or controlling for geographical regions when the outcome were mediators.

³Residual arrows were omitted.

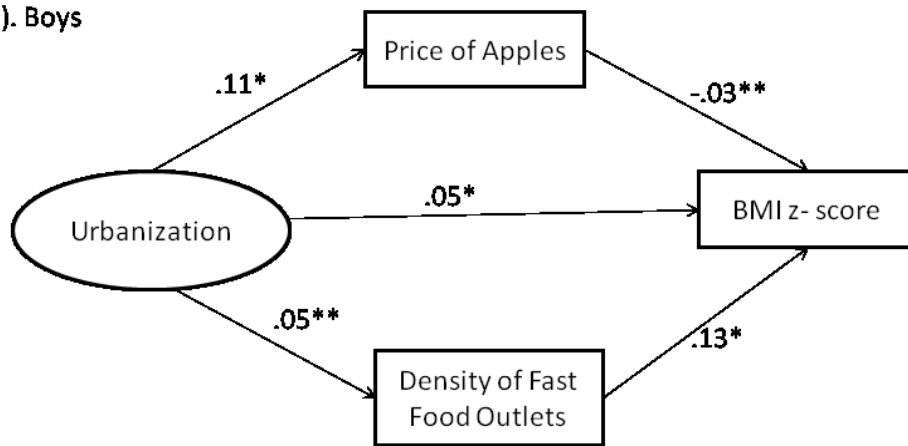
⁴Food prices were deflated to the year 2004 values using consumer price index (CPI).

Figure 6.3 shows the results of mediation analyses between urbanization and children's BMI z- scores and yielded different findings from that seen in Figure 6.3. It suggests that urbanization not only had a direct positive effect on boys' BMI z- scores (direct effect=0.05), but also influenced BMI z- scores indirectly through the price of apples (indirect effect=-0.0033) and density of FF restaurants in the neighborhood (indirect effect=0.0065). The pattern was different among girls: the effect of urbanization on BMI z- scores

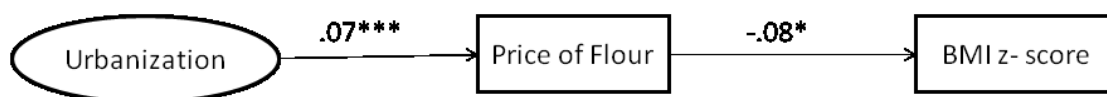
was fully mediated by the price of flour (indirect effect=-0.0056), and no direct effect was observed.

Figure 6.3. The Relationship between Urbanization and Chinese children's BMI Z- scores; Mediation of Food Environments based on Structural Equation Models, by Gender: CHNS 2004-2011^{1,2,3}

(a). Boys



(b). Girls



*p<0.05, ** p<0.01 *** p<0.001

¹Based on data from children aged 2-18, who participated at least twice in the China Health and Nutrition Survey (CHNS) in 2004, 2006, 2009 and 2011.

²Based on results from generalized structural equation models (*gsem*). Each arrow stands for a regression coefficient from a three- level multi- level linear regression analysis (children at different waves nested in communities) controlling for age, ethnicity, household income, mother's education and geographical regions when the outcome was BMI z- score, or controlling for geographical regions when the outcome were mediators.

³Residual arrows were omitted.

⁴Food prices were inflated to the year 2004 values using consumer price index (CPI).

DISCUSSION

This study suggests that urbanization in China was strongly and positively correlated with childhood obesity among boys, but not in girls in China. The association was especially related to the community economic status component of urbanization. The mediating effect of food environments was partly confirmed.

The Association between Urbanization and Weight Outcomes

Urbanization was found to be positively correlated with children's weight status and BMI z-scores, as reported by previous studies where urbanicity was treated as a dichotomous variable (M. Li, Dibley, Sibbritt, & Yan, 2007; Yu et al., 2012). A meta-analysis generalized findings from 13 papers published between 1981 and 2010, concluding that Chinese children living in urban areas were more likely to be overweight (OR= 1.66, 95% CI: 1.54~1.79) and obese (OR= 1.97, 95% CI: 1.68~2.30) compared to children living in rural areas (Yu et al., 2012). Some recent empiric studies also demonstrated a positive association between urbanicity and childhood obesity. For example, a cross-sectional study conducted among 1,804 adolescents in Xi'an reported living in urban areas increased the odds of being overweight or obese by three times, after adjusting for age and gender (M. Li et al., 2007). Another study on CHNS data focused on women from 1991 to 2011 suggested an interaction between baseline urbanicity and change in urbanicity among women only, as change in urbanicity from 1991 to 2011 was positively associated with the incidence of overweight among Chinese adult women in communities with low baseline urbanicity levels, was not associated with the incidence of overweight in communities with midrange initial urbanicity levels, and was negatively associated with the incidence of overweight in communities with high initial urbanicity levels (Gordon-Larsen et al., 2014). We could not conduct similar analyses due to small sample size of children available here, but additional analyses suggested a significant and positive association between the odds of being overweight and obese with baseline urbanicity levels in these data on Chinese children, but not with change in urbanicity (results not shown).

Mediation of the Food Environment of the Relationship between Urbanization and Weight Outcomes

The food environment appeared to mediate the relationship between urbanization and childhood obesity in China, but no consistent patterns were found. Among boys, urbanization appears to have a direct effect on

the odds of being overweight or obese (or BMI z- scores themselves), but urbanization may also influence obesity indirectly through prices of apples, density of FF restaurants and/or community norms for nutrition knowledge. Among girls, the price of flour fully mediated the association between urbanization and the weight outcomes examined here.

The direct effect may be explained by the dramatic change in lifestyles coinciding with urbanization. One study using data from the Chinese National Nutrition and Health Survey indicated a shift in dietary patterns as a result of urbanization from predominantly plant- based to a more animal- based diet (Zhai et al., 2014). This dietary shift was also characterized by increased intakes of fats and refined grains, as well as changes in food cooking and preparing methods from steaming or boiling to stir- frying, which all contribute to childhood obesity (Zhai et al., 2014). Western FF consumption also increased with urbanization: less than one in fifth school- age children have consumed Western FF in the past three months in 2004, compared to one in fourth in 2009 (Xue et al., 2016). In addition, Popkin's research suggests that among Chinese adults, physical activity (PA) levels have declined with urbanization, tracing this to a drop in occupational PA, less time spent in leisure- time activities, and more automobiles instead of riding bicycles or walking (Samantha M. Attard et al., 2015; S. W. Ng et al., 2009; Popkin, 1999). It is very likely that such shifts in diet and PA further increased the rates of childhood obesity in China (Zhang et al., 2015).

Urbanization may have also contributed to Chinese children's weight problems indirectly, through the food environment. Previous studies have provided some insights into the potential relationship between urbanization, the food environment, and children's weight status, but most did not look at these factors simultaneously. For example, our previous study indicated a close relationship between urbanization and the three dimensions of the food environment based on analyses from 216 communities included in the 1989-2009 CHNS. We found urbanization increased the odds by more than two folds of having FF restaurants and other indoor restaurants within the community, as well as having supermarkets and free

markets within 30 minutes' bus ride of the community. It also stimulated the economy at the community-level, as shown by increased food prices for certain foods (apples and pork). Urbanization was also found to be positively associated with community norms for greater levels of FF consumption, FF preferences, and nutrition knowledge (Wu et al., 2016). Another study using CHNS 1991- 2000 data suggested that as a result of urbanization, pricing policies were implemented, such as policies to bring down the prices of edible oils, which stimulated edible oil consumption, and thus a shift to an animal- based diet, contributing to population weight gain (Ng et al., 2008).

Whether the food environment is associated with childhood obesity remains controversial, even in affluent, developed countries. A recent review summarized evidence from 33 studies and found conflicting evidence of the relationship between FF outlet availability and weight status (Fraser et al., 2010). Such studies are rare in developing countries like China. One recent study conducted latent- class analyses based on 9,788 adults from CHNS 2006 and showed a link between higher BMI and a poor retail food environment (X. Zhang et al., 2012). The inconsistency may be a result of a too- narrow definition of food environment, since most previous studies only explored the “physical environment,” and thus ignored the effects of other dimensions of the food environment, such as the economic environment and socio- cultural environment, which we found in this study to be important mediators.

Prices of apples and flour were found to be negatively correlated with children BMI z- scores and mediated the relationship between urbanization and children's BMI z- scores. Prices of staple foods (including flour) were shown to be positively associated with body fat in 15,000 Chinese adults participating in CHNS 1991-2006 (Lu & Goldman, n.d.). It is assumed that increased flour prices subsequently decreased the consumption of flour, and potentially led to decreased energy intake and BMI z- scores. However, our findings differ from evidence from the National Longitudinal Survey of Youth in the U.S., in which a 10% increase in the price of fruits and vegetables was found to be related to a 0.7% increase in American

children's BMI (POWELL & CHALOUPIKA, 2009; Powell & Bao, 2009). Further studies will thus be needed to better understand how food prices mediate the relationship between urbanization and children's weight outcomes.

The inverse relationship we found between childhood obesity and deficiencies in nutrition knowledge at the community level contrasts with some previous findings that childhood obesity was correlated with poor nutrition knowledge at the individual level (Zhang et al., 2012). We shall note there is a mismatch between worse childhood obesity problems in communities and greater nutrition knowledge (people at the same time favoring FF in their diets). It suggests that Western FF consumption has not been sufficiently linked to obesity by the general public in China, and thus is not recognized as a problem.

Though not confirmed in this study, the three dimensions of the food environment may act together to mediate the relationship between urbanization and childhood obesity. For example, urbanization is more likely to be highly correlated with childhood obesity among children living in communities with better access to FF restaurants and preferring FF, as compared to those who living in communities favoring FF but where there are no access to FF restaurants. Further studies are needed to explore such inter-correlations.

Gender Disparity in the Association between Urbanization and Weight Outcomes

Gender difference existed in susceptibility to the adverse effects of urbanization, as boys living in urbanized areas were more prone to be overweight or obese than girls living in the same areas. The gender difference has been reported elsewhere- notably a study on 231,326 school-age children participating in the 2005 Chinese National Survey on Student's Constitution and Health study, where boys were found to be more likely to become obese (Chen, Modin, Ji, & Hjern, 2011). Compared to boys, girls have more protective factors against being overweight, such as differences in body composition, and that the ideal female body image in China is slimness.

Meanwhile, Chinese boys generally consumed more fruits and presumably were more susceptible to price change in fruits. A study based on CHNS 1991- 2009 examined the temporal trends in fruits and vegetable intake among Chinese children aged 6- 18. It showed that the median intake of fruits was 133.3 g/d in boys, compared to 124.2 g/d in girls (Zhang et al., 2015). Thus, Chinese boys consumed more fruits (including apples) than Chinese girls, and their fruit intake was more subject to price change in fruits.

Key Study Strengths and Weakness

To our knowledge, this is the first study to identify how urbanization in China correlates with the food environment, as well as children's rates of overweight or obesity and we used nationwide longitudinal survey data. Its key strengths include a large, nationwide sample with detailed regional data, and follow- ups spanning four waves spanning seven years. In addition, this is the first study that examined how the food environment mediates the relationship between urbanization and Chinese children's weight status or BMI z-scores, which attempted to understand the mechanisms by which urbanization impacts childhood obesity rates. It also takes a broader view of the food environment, also taking into account its economic and socio-cultural components. Finally, it examined the association between children's weight outcomes and different dimensions of urbanicity, and found the community- level economic status to be a critical contributor to childhood obesity.

This study also has some limitations. We could not control for community- level SES, a potential confounder of the relationship between urbanicity and weight outcomes. However, two components of the urbanicity index, economic activity and education, can largely substitute for community- level SES. Next, we need to be cautious about the low follow- up rate and differences in socio- demographics and food environment characteristics between children who were included and not included in this study, especially when generalizing our findings to the entire population of Chinese children. Finally, urbanicity was treated

as a time- dependent variable in the regression and mediation analyses, making it difficult to distinguish between the effects of baseline urbanicity and changes in urbanicity. However, we conducted some additional analyses in an attempt to separate the effects of baseline urbanicity and change in urbanicity and this yielded similar findings.

Public Health Implications

Our findings suggest that the key factors to consider when devising policies and interventions to address the rapid increase in childhood obesity occurring in China should take into account urbanization and the food environment, especially the economic growth in urban and rural regions. Preventive interventions directed at the environment, agricultural and pricing policies have the potential to curb childhood obesity in China. For example, raising the prices of obesogenic foods (e.g., FF) and reducing the prices of healthy foods (e.g., apples) may potentially modify their dietary patterns towards a healthier diet. Besides, regulations are needed to control the clustering of Western FF restaurants near kindergartens and schools.

Moreover, though previous social marketing and health campaigns have equipped people with more nutrition knowledge, they have not helped to raise the general public's awareness of the adverse health effects of Western FF. Further educational campaigns should raise public awareness of the threats of Western FF to health.

Further, prevention and intervention programs need to be tailored by gender. One explanation for the higher prevalence of overweight or obesity among boys than girls in China may be higher susceptibility to the adverse effects of urbanization and the local food environment among boys. Girls may be less prone to environmental cues, and are culturally driven to stay fit and thin. Public health professionals and policy makers may achieve better outcomes by tailoring their interventions to boys and girls based on these realities.

Conclusions

This study shows childhood obesity was associated with urbanization in Chinese boys, but not girls, particularly regarding the related economic component of the food environment. This relationship was partially mediated by the food environment, but the findings were inconsistent regarding which components of the food environment played a role. The potential candidates include: nutrition knowledge within communities, prices of apples and density of FF outlets. More studies are needed to better understand the relationship and related mechanisms between urbanization and childhood obesity in China.

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CHAPTER 7: CONCLUSIONS

7.1 Summary of Key Research Findings

This study supports our hypothesis that urbanization is associated with the changing food environment, as well as increased rates of Western FF consumption and overweight/ obesity in children in China. It partially substantiates the hypothesis that the food environment mediates the relationship between urbanization and children's Western FF consumption and weight status.

Findings from Chapter 4 (Research Paper 1, already published) suggest that urbanization in China is associated with all aspects of the community-level food environment we examined. That is, urbanization increased the odds of having FF restaurants (OR=2.78, 95% CI: 2.18-3.54) and other indoor restaurants (OR=2.93, 95% CI: 2.28-3.76) within the community, as well as the odds of having supermarkets (OR=2.43, 95% CI: 2.04-2.89) and free markets (OR=2.56, 95% CI: 1.77-3.70) within 30 minutes' bus ride from the community. Food prices for apples (β =0.06, 95% CI: 0.04-0.08) and lean pork (β =0.02, 95% CI: 0.01-0.03) also increased with urbanicity, while prices for other foods did not. Urbanicity was positively associated with community norms for FF consumption (RR=1.28, 95% CI: 1.22-1.33), FF preferences (RR=1.09, 95% CI: 1.06-1.12) and nutrition knowledge (RR=1.02, 95% CI: 1.01-1.03).

In Chapter 5 (Research Paper 2), our longitudinal data analyses and structural equation modeling on 1,407 children enrolled in CHNS 2004- 2011 showed that children in more urbanized communities were more likely to consume Western FF. This held true for both boys (OR=1.98, 95% CI: 1.68~2.35) and girls (OR=1.88, 95% CI: 1.60~2.22). Some components of the socio-cultural and economic environments seem to mediate these associations, but no consistent pattern was found.

In Chapter 6 (Research Paper 3), we used longitudinal data collected from 1,878 individuals between ages two and 17 in CHNS 2004-2011, and found that urbanicity was positively associated with the odds of

being overweight or obese among boys (OR=1.38, 95% CI: 1.13-1.67), but not girls. The economic component of urbanicity was found to be significantly related to childhood obesity (OR=1.11, 95% CI: 1.00-1.22). Structural equation modeling revealed that the density of FF outlets, food prices for apples or flour, and community norms for nutrition knowledge may mediate this relationship.

7.2 Key Study Strength and Limitations

This study is an initial attempt to investigate the impact of urbanization on Chinese children's dietary intake and weight status, as well as the mediating effects of different dimensions of the community-level food environment, including the physical, economic and socio-cultural environments. Second, the CHNS is currently one of the largest nationwide, cohort studies on nutrition and health in China. It includes nine survey waves from 1989 to 2011 and gathers rich information on environmental, behavioral and biological factors from the community-, household-, and individual-levels. Third, this study explored the underlying mechanisms of childhood obesity from a community perspective, which has the potential to strengthen our understanding of the underlying causes of the childhood obesity epidemic in China.

The study also has limitations. First, it is not a nationally representative study sample. Thus, it may be incorrect to generalize the findings to the entire country. Second, other than the physical (local food environment) and economic environment (food prices), other contextual factors may also play a vital role in obesity, such as food policy, and FF marketing (Feng et al., 2010). Future studies should take these additional factors into consideration to more fully understand the complex emerging dynamics of childhood obesity in China.

7.3 Implications

Cross-national comparisons have indicated three stages of urbanization in China: a rapid-decline stage

from 1960 to 1978; a stable stage of slowly rising urbanization from 1979 to 1995, and a rapid- promotion stage from 1996 to date. Though urbanization and economic growth initially appeared to go hand- in- hand, urbanization began to exceed economic growth after 2004, with calls for more attention to be paid to rapid urbanization and its threat to population health (Chen et al., 2013).

This study calls on attention to urbanization in China, recognizing its beneficial effects on gross domestic product (GDP), number of buildings, paved roads and urban population growth, but also acknowledging its detrimental effects on population health. Urbanization in China has brought problems related to high temperatures and pollution, as well as raising the risk of NCDs. Childhood obesity is a critical driver of NCD risk.

Public health professionals and policy makers need to design intervention programs, as well as to enact new city planning, zoning and pricing policies to minimize the potential adverse effects of urbanization. For example, a closer scrutiny is necessary before permitting the opening of a new Westernized FF restaurant near a school, or in a residential area with many children.

Though Western FF consumption is currently not the major risk factor of childhood obesity and NCD in China, its impact is growing with the rapid spreading of Western FF industry and its indirect impact on local food across China. In 2011, over a half of urban children consumed Western FF in the past three months, while only one- in- five rural children reported doing so. Since all components of the food environment mediate this relationship between urbanization and FF consumption, work is needed to in the areas of city planning and food pricing, as well as altering community norms. Education programs and public service announcements (PSAs) can be utilized as a means of educating children and their parents about the adverse health effects of Western FF. Regulations may also be called for to minimize the impact of FF industry advertising to children.

Moreover, our research findings indicate that future obesity interventions need to be tailored by

children's gender and age. Boys appear to be more sensitive to the detrimental effects of urbanization on their weight than girls, and the mediation effects of the food environment also differ by gender.

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Work Experience

Research Assistant & Project Coordinator

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Collect information and compile reports, peer-review papers and monthly project updates; design, revise and translate questionnaires and workbooks for fieldwork; interview candidates; manage group teams; set up regular meetings and teleconferences with both domestic and international collaborators; keep track of project progress.

- *Multilevel Systems-oriented Childhood Obesity Study In China (NIH/NICHD), 2011-2016*

Research Assistant & Project Coordinator

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Manage project, collect information and compile reports and peer-review papers, help to conduct analysis and write reports.

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Research Assistant

Asian American Liver Cancer Education Program in Maryland

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Conduct fieldwork and health education in Chinese churches and language schools to evaluate the effectiveness of an education program aiming to raise the awareness of hepatitis B screening among Asian Americans, manage and analyze data, attend weekly conference calls.

Teaching Assistant

Bloomberg School of Public Health, Johns Hopkins University

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Lead & facilitate classroom discussions, lecture, grade exam papers & course projects for courses including “integrating social and behavioral science into public health”, “biostatistics in public health”, “persuasive communication”

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Select Publications & Presentations

1. Peer- review Papers

- ◆ **Wu Y**, Xue H, Wang H, Su C, Du S, Wang Y. The Impact of Urbanization on Community Food Environment in China. *Asia Pacific Journal of Clinical Nutrition*. 2016;(epub):d1–20.
- ◆ Xue H, **Wu Y** (co- first author), Wang X, Wang Y. Time Trends in Fast Food Consumption and Its Association with Obesity among Children in China. *PLoS One*. 2016;11(3):e0151141.
- ◆ Cai L, **Wu Y**, Wilson RF, Segal JB, Kim MT, Wang Y. Effect of childhood obesity prevention programs on blood pressure: A systematic review and meta-analysis. *Circulation*. 2014;129(18):1832–9.
- ◆ Cai L, **Wu Y**, Cheskin LJ, Wilson RF, Wang Y. Effect of Childhood Obesity Prevention Programmes on Blood Lipids: a Systematic Review and Meta-analysis. *Obesity Reviews*. 2014;15(12):933–44.
- ◆ Wang Y, Cai L, **Wu Y**, Wilson RF, Weston C, Fawole O, et al. What Childhood Obesity Prevention Programmes Work? A Systematic Review and Meta-analysis. *Obesity Reviews*. 2015;16(7):547–65.
- ◆ Bleich SN, Segal J, **Wu Y**, Wilson R, Wang Y. Systematic Review of Community-based Childhood Obesity Prevention Studies. *Pediatrics*. 2013;132(1):e201–10.
- ◆ Showell NN, Fawole O, Segal J, Wilson RF, Cheskin LJ, Bleich SN, **Wu Y**, et al. A Systematic Review of Home-based Childhood Obesity Prevention Studies. *Pediatrics*. 2013;132(1):e193–200.

2. Reports

- ◆ Wang, Y., **Wu, Y.**, Wilson, R. F., Showell, N., Weston, C., Bleich, S., et al. Childhood Obesity Prevention Programs: A Comparative Effectiveness Review and Meta-Analysis. (Prepared by the Johns Hopkins University Evidence-based Practice Center under Contract No. 290-2007-10061-I.) Rockville, MD: Agency for Healthcare Research and Quality, June, 2013. www.effectivehealthcare.ahrq.gov/reports/final.cfm.
- ◆ **Wu, Y.**, Lau, B. D., Bleich, S. N., et al. Research Needs for Childhood Obesity Prevention Programs. Future Research Needs Paper No. 31 (Prepared by the Johns Hopkins University Evidence-based Practice Center under Contract No. 290-2007-10061-I.) Rockville, MD: Agency for Healthcare Research and Quality, June, 2013. www.effectivehealthcare.ahrq.gov/reports/final.cfm.

3. Conference Presentations

- ◆ **Wu, Y.**, Xue, H., Du, S., Wang, H., Zhang, B., Cheskin, L. J., & Wang, Y. (2013) *The Impact of Urbanization on Community Food Environments: Results from the China Health and Nutrition Survey*. Oral Presentation at the Obesity Society Annual Meeting, Atlanta, GA.
- ◆ **Wu, Y.**, Du, S., Wang, H., Zhang, B., & Wang, Y. (2013) *Parent-Child Resemblance in Dietary Intakes, Body Mass Index and Blood Pressure in China*. Poster presentation at the Experimental Biology Annual Meeting, Boston, MA.